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JOHN H. GIBBON, JR., M.D.  
Recorder of the American Surgical Association

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# ANNALS OF SURGERY

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## RADICAL SURGERY FOR CERTAIN CASES OF PANCREATIC FIBROSIS ASSOCIATED WITH CALCAREOUS DEPOSITS\*

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PRESENT-DAY ADJUVANTS to the surgeons' armamentarium in the pre-operative, operative, and postoperative periods have made radical operations feasible which ten years ago were considered impossible. In certain fields, such as in primary cancer surgery, these extensive procedures are justified where the wide removal of possible cancer-bearing tissue insures a more certain arrest of the tumor. Or, where with a hazardous operation, technically difficult, a readjustment of the circulation by vascular anastomosis corrects a hopelessly deranged physiology.

The pancreas is one of the organs which in recent years has been dealt with radically in an attempt to cure otherwise hopeless disease and in the past three years total pancreatectomy has been successfully accomplished with surprising results in some instances. Priestley<sup>1</sup> was the first surgeon to achieve this success in a patient with severe hypoglycemia after a thorough exploration of the organ had failed to reveal an islet cell tumor. This patient is cured of her hypoglycemia 36 months after operation, and does not require as much insulin as many a diabetic. To date, 14 total pancreatectomies have been performed, and are recorded in Table I.

The first successful total pancreatectomy for chronic pancreatitis associated with extensive calcareous deposits was performed by Claggett<sup>2</sup> in November, 1944. This patient was relieved of her unbearable pain. Ten weeks later, while in her home, she developed a severe hypoglycemic reaction which was not recognized, resulting in death. Her diabetes was controlled by a daily dose of eight units of protamin-zinc insulin and 30 units of regular insulin taken in one injection in the morning.

We wish to record two of these total pancreatectomies and three other radical procedures with removal of a large part of the organ for intolerable pain associated with pancreatic fibrosis and calcareous deposits and pancreatic calculi (Table II).

\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

We do not intend to review the subject of pancreatic lithiasis in this paper. The subject has been recently summarized in papers by King and Waghelstein<sup>3</sup> in 1942 and by Lionello, Ficcara and Ryan<sup>4</sup> in 1944. But we wish to emphasize certain points in the indications for radical resection of the pancreas for this condition.

Extensive calcification of the parenchyma of the organ is rare as compared to the finding of numerous calculi in the ducts. Fibrosis of a part of the organ is frequently associated with either calcification or calculi. Cystic degeneration or dilatation of the obstructed ducts is usually present. Disturbed carbohydrate metabolism in the form of mild diabetes is found in about a third of the cases. The same is true of abnormal fat digestion and

TABLE I

CASES OF TOTAL PANCREATECTOMY PREVIOUSLY REPORTED AND INCLUDING TWO CASES BY THE AUTHOR

Author	Age	Sex	Diagnosis	Survival After Operation	Approximate Insulin Daily Dosage
1. Rockey <sup>6</sup> , 1943	51	M	Carcinoma pancreas	15 days—died	27 units
2. Goldner and Clark <sup>6</sup> , 1944			Carcinoma pancreas	11 days—died	20 units
Case of Brunschwig					
3. Goldner and Clark <sup>6</sup> , 1944	45	M	Carcinoma bile duct	10 days—died	40 units
Case of Clark					
4. McClure <sup>7</sup> , 1944 (Case of Fallis)	46	M	Carcinoma pancreas	Alive 9 mos. after operation	26–34 units
5. Brunschwig, <i>et al.</i> <sup>8</sup> , 1945	53	M	Carcinoma pancreas	Died 3.5 months after operation	40 units
6. Priestley, <sup>1</sup> 1942	49	F	Islet cell adenoma	Well after 3 years	18–25 units
7. Waugh, <sup>2</sup> 1944	36	F	Islet cell adenoma	Well 8 mos. after operation	32 units
8. Dixon, <sup>2</sup> 1944	50	M	Carcinoma of pancreas	15 mos. after operation showed recurrent abdominal mass, anemia and jaundice	40 units
9. Claggett, <sup>2</sup> Nov. 1944	37	F	Chronic pancreatitis with calcification	2.5 mos. after operation died in an hypoglycemic attack	38 units
10. Zininger <sup>9</sup> , 1945	39	M	Chronic pancreatitis with pancreatic lithiasis	Died after operation 30 hours	30–50 units
11. Brunschwig, <sup>10</sup> 1944	67	M	Carcinoma pancreas	3 days—died	
12. Brunschwig, <sup>11</sup> 1946			Carcinoma pancreas	14 days—died	
13. Whipple, 1945	26	F	Pancreatic calculi	12 mos. Relieved of pain	30–80 units
14. Whipple, 1945	46	F	Pancreatic calculi	7 days—died	20–40 units

Included in  
Table II of  
this paper

abnormal stools. Mild pain in the epigastrium or a sense of nagging epigastric distress is present in the majority of the patients. It may appear intermittently with periods of complete freedom or it may be fairly constant. In some patients, however, and not corresponding necessarily with the extent of calcareous deposits in the pancreas, the pain is so severe and constant, frequently radiating through to the back, as to be intolerable and morphinism is a serious threat. A history of a previous acute pancreatitis or of chronic alcoholism is common. The most important laboratory examination is a plain film of the upper abdomen to demonstrate the presence and extent of the calcareous deposits which may appear in the head, the body,

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TABLE II  
RADICAL RESECTIONS OF THE PANCREAS, BY THE AUTHOR, FOR PANCREATIC LITHIASIS

Unit No.	Sex	Age	Duration of Severe Epigastric Pain	Previous Acute Pancreatitis	Deficient Panc. Ferments	Roentgen Ray Evidence of Calculi	Pancreaticoduodenectomy	Total Panc.	Follow-up Result
671642	M	42	9 months	No previous operation	Markedly in all 3 ferments	Positive in head of pancreas	Head and all of duodenum and antrum of stomach		2 yr. F.U. Relieved of pain. Normal digestion working at full capacity
672681	M	48	6 years	9 mos. previously operation showed edema and large head pancreas	Markedly in all 3 ferments	Positive in head of pancreas	Head, all of duodenum and antrum		3 yr. F.U. Relieved of all former pain. Normal digestion. 98 per cent fat absorption
754745	M	45	5 years	4 mos. previously at operation a large mass was found in head	Markedly in all 3 ferments	Calcium shadows outline shape of pancreas	Total duodenectomy, antrum of stomach. Splenectomy. All of pancreas save a strip over superior mesenteric vessels		Several postoperative visits, last one 20 mos. after operation. Relieved of epigastric pain. Takes capsules of pancreatin to maintain fat digestion
762485	F	26	10 mos.	1 yr. ago in Harlem Hosp. for acute abdomen. Diag.: probable poisoning	Marked deficiency in all 3 ferments	Calcium shadows outline all the pancreas	Total pancreatectomy. Total duodenectomy. Resection of antrum of stomach		5 mos. later developed active pulmonary Tbc. 1 yr. postop. is in tuberculosis hosp. Requires 30-80 units of insulin to control her diabetes. Entirely free from pain
784094	F	46	10 weeks	No history of previous pancreatitis. 5 wks. ago. Celiotomy revealed large pancreas that "felt like a bag of shot"	Markedly in all 3 ferments	Calcium shadows outline entire shape of pancreas	Total pancreatectomy. Splenectomy. Total duodenectomy. Resection of antrum of stomach		Patient died on 7th day after operation. Autopsy revealed a localized bile peritonitis and a thrombosis of large branch of portal vein



FIG. 1



FIG. 2

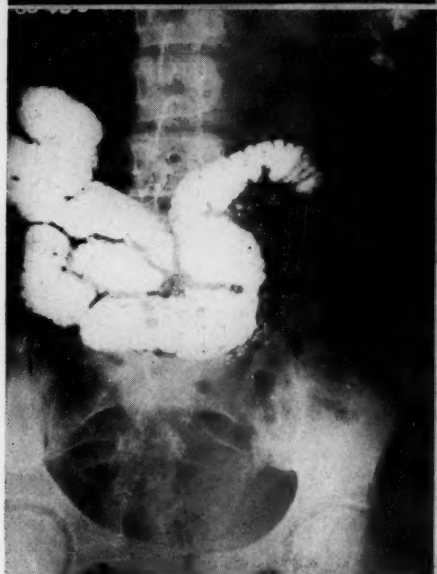


FIG. 3



FIG. 4

- FIG. 1.—C. F. Unit #672681. Case 2. X-Ray film showing calculi in head of the pancreas.  
 FIG. 2.—I. S. Unit #762485. Case 4. X-Ray film showing calculi throughout the entire pancreas, before operation.  
 FIG. 3.—I. S. Unit #762485. Case 4. X-Ray film of abdomen taken after operation.  
 FIG. 4.—B. B. Unit #784094. Case 5. X-ray film of abdomen showing calculi throughout the pancreas, before operation.

or the tail of the pancreas, or the entire organ may be outlined by the calcareous material (Figs. 1-6). Next in importance is the finding of a marked deficiency in one or more of the pancreatic ferments, as determined from duodenal aspiration with the administration of metholyl chloride.

Many patients with mild epigastric distress or intermittent pain showing roentgenologic evidence of varying degrees of calcareous deposits are amenable to dietary and medical regimen, and may go for a period of years

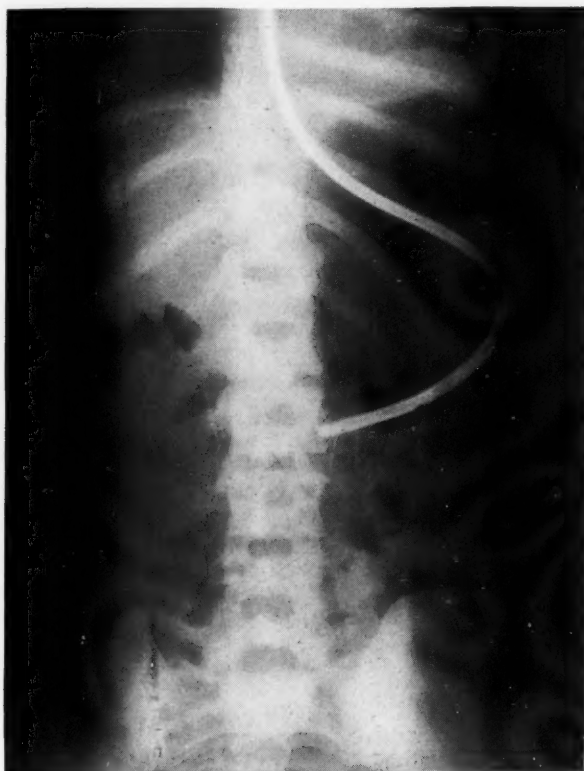


FIG. 5.—B. B. Unit #784094. Case 5. X-Ray of abdomen taken after operation.

with tolerable symptoms. There are a few patients, however, that fail to respond to conservative therapy and develop such severe recurring or constant pain, requiring hypodermic medication, that life becomes intolerable. It is for such patients, in whom the diagnosis of pancreatic calculi and chronic pancreatitis is established roentgenologically and by pancreatic function tests, that radical resection and even total pancreatectomy is indicated and welcomed by the victim of the disease.

In all five of our patients pain was dramatically relieved. Claggett's<sup>2</sup> patient, in her own words, had been given a new lease on life with the relief of pain. One of our patients had, of necessity, retired from an active busi-

ness and since his operation for the past three years has enjoyed his winters in Florida and his summers in Wisconsin.

The extent of removal of pancreatic tissue in these radical procedures, is determined by the part of the organ showing the calcareous material as seen in the roentgenograms and by the amount of fibrosed tissue. In the cases with the involvement of the head of the organ we have carried out a pancreaticoduodenectomy, as for a carcinoma of the head. In the tail or body we have left the head but have removed the remainder of the organ with the spleen, as the splenic vessels are usually embedded in the fibrosed tissue. In one of our patients we left only a small strip of pancreatic tissue over the superior mesenteric vessels.

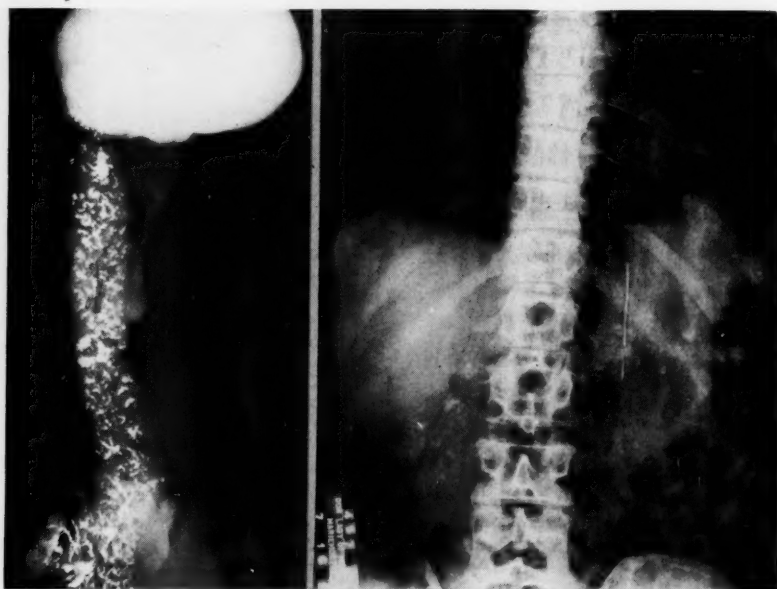


FIG. 6.—Patient of Dr. Zininger, by permission. X-Rays of abdomen before operation. X-Ray of specimen of pancreas removed at operation.

These patients all require transfusion therapy during and after operation. We have used silk technic throughout but have used "near-and-far" steel wire closure of the incision through all the layers because of the possibility of temporary bile and pancreatic ferment leakage and to avoid wound disruption. A small rubber tube within a large rubber tube (Fig. 7) for suction drainage is used to insure dry dressings, to avoid skin irritation and, if necessary, to measure bile or pancreatic juice leakage.

In the patients with total pancreatectomy it is essential to have the close coöperation of an internist experienced in the treatment of diabetes in the pre- and postoperative periods. But it has been astonishing in many of the reported cases to note the relatively small insulin requirements of these patients after a total pancreatectomy. It has caused new theories in the minds of physiologists, internists and surgeons.



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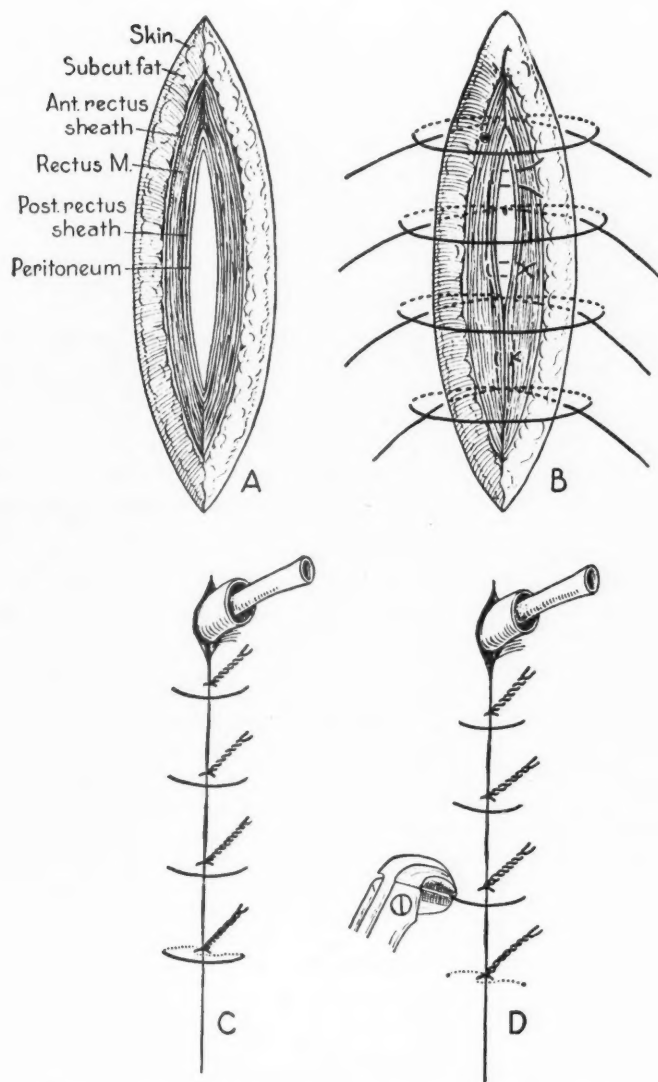


FIG. 7.—“Near and Far, Far and Near” Steel Wire Sutures through all layers for closure of abdominal incision.

Before approximating the wound edges by drawing up and twisting the ends of the steel wires, it is advisable to use interrupted mattress silk or cotton sutures to unite the peritoneum and posterior rectus sheath. No other sutures are necessary for the other layers. The “near and far” wire sutures do not cut the tissues as much as the ordinary retention sutures because the tension is distributed on four rather than on two points. The cross bar of the steel wire is cut at the skin level on the tenth to twelfth day. The next day the twisted ends can be removed.

CASE 1.—Unit No. 671642: F. W., age 42, white, male, salesman. Chief complaint: Attacks of epigastric pain, nine months. F.H. noncontributory. Past: Typhoid at 12. Rheumatic fever at 14. System review irrelevant.

*Present:* He has had vague indigestion for several years. In July, 1941, he had his first attack of midepigastric pain. Cramp-like, later becoming constant, radiating into the back, so severe as to require morphine hypodermically. In November, 1941, February and March, 1942, he had three similar attacks, pain and marked distention, lasting several days with complete relief with morphine, and no symptoms between attacks. No jaundice. Roentgenologic studies taken in Stamford Hospital were not informative. Was treated for neurosis. Physical examination: T.P.R., B.P. normal. No jaundice. Head, neck, chest, extremities, negative. Abdomen: Tenderness and a vague mass in the epigastrium.

*Laboratory Studies:* Blood picture and urinalysis are normal. Fasting blood sugar, 95 mg. per cent. Blood amylase, 61 M.K. units definitely elevated. Pancreatic ferment tests with metholyl chloride show marked deficiency in all three ferments. Duodenal bile examination shows no crystals. Roentgenologic studies show some displacement of the duodenum and stomach and vague shadows suggestive of calcified areas in the head of the pancreas.

*Operation*—5/11/42: Pancreaticoduodenectomy (resection of the antrum of stomach, all of duodenum, 12 cm. of the jejunum, part of common duct) with cholecystectomy, gastrojejunostomy, pancreaticogastrostomy.

*Findings:* The head of the pancreas was indurated, edematous, so hard that it was thought to be malignant. The true nature of the lesion was not discovered until the pancreas had been divided through the body, where it was found that there were multiple areas of calcification and dilated ducts. Liver and biliary tract appeared normal. Because the lesion in the pancreas was considered malignant the above procedures were carried out.

*Summary of Pathologic Report:* On opening the ducts in the head of the pancreas numerous calculi are found, some of them embedded in the wall of the duct. These vary from 1-4 mm. Numerous areas of focal necrosis are present which show remnants of calculi and epithelium. All sections show an extreme grade of fibrosis of the parenchyma of the organ.

*Postoperative Course:* This was very stormy, with a spiking temperature for three weeks. For a few days his blood cultures showed *B.coli*. He developed a pancreatic fistula. Stools were normal in color and consistency, however. He was discharged on his 36th day. Pain had been entirely relieved.

11/24/42: He was readmitted for closure of his pancreatic fistula. This was done by transplanting the fistulous tract into the loop of jejunum distal to his cholecystectomy. Recovery uneventful. No recurrence of pain.

6/14/44: Two years after operation: Feels well, no pain, no indigestion. He has regained normal weight. Stools normal. No recurrence of fistula.

CASE 2.—Unit No. 672681: Admitted 5/25/42. C.F., age 45, white, male, manufacturer. Chief complaint: Epigastric pain, six years. F.H.: Irrelevant. Past: Appendectomy at 21. Influenza at 24. System review negative.

*Present:* Six years ago he began having intermittent attacks of epigastric pain, colicky in type, at times very severe. Not related to meals. No jaundice until nine months ago when with an acute attack he developed jaundice and signs of acute cholecystitis. Cholecystectomy was performed by Dr. Evans, of Milwaukee, who found an acute gangrenous, noncalculous, cholecystitis together with edema and marked induration and enlargement of the head of his pancreas.

He improved for four months, but in November, 1941, some seven months before admission, he began having very severe epigastric pain radiating to the back, which at times required morphine hypodermically. Roentgenologic studies showed calcified

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areas in the head of his pancreas which did not appear before his cholecystectomy. Because of the severe pain and the dread of morphine, he was referred to the Presbyterian Hospital for study and treatment.

*Physical Examination:* T.P.R. normal. B.P. 150/100. Wt. 130 lbs. A well-developed, well-balanced male. No jaundice. Head, neck, chest and extremities normal. The abdomen shows right rectus R.L.Q. scars, and a questionable mass in the epigastrium.

*Laboratory Studies:* Blood picture normal. Urinalysis, normal. Pancreatic function test with mecholyl chloride shows very low values for all three ferments. Serum amylase: 30.9 Myer-Killian units (at upper limit of normal).

*Glucose tolerance test:* Indicates disturbed carbohydrate metabolism as seen in latent diabetes. Roentgenologic studies show a collection of calcium shadows in the head of the pancreas. The study indicates definite pathology in the head of the pancreas.

*Operation.*—5/26/42: Pancreaticoduodenectomy (resection of the head and part of the body of the pancreas, the pylorus, all of the duodenum, first 10 cm. of the jejunum and part of the common duct). Gastrojejunostomy, choledochojejunostomy, implantation of the pancreatic duct into loop of jejunum.

*Findings:* The major part of the pathology was found in the head of the pancreas where there were numerous calcified casts of the branches of the pancreatic duct, with marked induration of the head which on biopsy showed no tumor. The pancreatic duct and the common duct were markedly dilated. Gallbladder was absent. Liver appeared normal, showing no evidence of fatty degeneration.

*Pathologic Report:* Summary, this appears to be very extensive chronic fibrous pancreatitis with pancreatic calculi in dilated obstructed ducts. The common duct showed no stones. There was no evidence of tumor tissue in any of the many sections examined, but all sections of the pancreas showed fibrosis of the parenchyma.

*Postoperative Course:* Was much smoother than was expected. Wound healed kindly. No fistulae. Pain was entirely relieved. Bowel movements, one a day, appeared normal. Discharged on his 23rd day.

*Follow-up.*—2/27/45: Two years, nine months, after operation came in for a check-up. He has maintained his weight, has no indigestion, no food intolerance. His former pain has been entirely relieved. Blood studies are normal. Fat absorption study: On a three-day measured fat intake and output test he shows 98 per cent fat digestion.

5/26/45: Three years after operation, letter from patient states he feels well and has had no recurrence of pain.

CASE 3.—Unit No. 754745: Admitted 7/20/44. C. H., age 45, white, male, machinist. Chief complaint: Severe epigastric pain at irregular intervals for five years. F.H. Irrelevant. Past: Typhoid fever and osteomyelitis of tibia 16 years ago.

*Present:* In 1901, cholecystectomy and appendicectomy were done for lower abdominal pain in another hospital. In 1939 he began having severe, gnawing pain in epigastrium and left upper quadrant, radiating to the back. In 1941, this pain became very severe and during the two weeks of the attack he lost 20 lbs. For three years he improved but pain persisted. In February, 1944, the pain recurred in very severe form, and he developed jaundice. In March, 1944, he was operated upon in Washington, D. C. An orange-sized, hard mass was found in the head of the pancreas which appeared calcified. The common duct was drained by a T-tube. Because of persistent pain requiring morphine he was referred to the Presbyterian Hospital.

*Physical Examination:* A tall, thin male complaining of pain in L.U.Q. No jaundice. Head and chest and blood pressure are normal. The abdomen reveals two right rectus scars, the mesial one wearing a T-tube. There is tenderness along the epigastrium and L.U.Q.



*Laboratory Data:* Blood count and blood picture is normal. Urinalysis shows no albumin or sugar. Fasting blood sugar, 97 mg. per cent. Serum amylase 42 Myers-Killian units. Pancreatic function test with 10 mg. mecholyl chloride shows marked deficiency in all three ferments, indicating wide spread disease. Duodenal bile drainage: Light green. No crystals. Roentgenologic studies show a series of calcium shadows occupying the position of the pancreas. These shadows vary in size, some as large as 4 x 7 mm. Some of these in the head of the pancreas suggest the outline of a cyst.

*Operation.*—7/29/44: Pancreaticoduodenectomy, splenectomy, resection of tail and most of the body of the pancreas (the only part remaining was a narrow strip overlying the superior mesenteric vessels). Cholechojejunostomy. Gastrojejunostomy. Incision: Transverse.

*Pathology:* The findings in this patient corresponded fairly accurately with those that had been reported in his previous operation by Dr. Anderson. There were very dense adhesions between the colon and omentum, and omentum to anterior abdominal wall, and under surface of the liver and duodenum which required a good hour of careful dissection in order to determine the feasibility of a radical procedure. The pathology in the pancreas was exceedingly interesting. The mass in the head of the pancreas had decreased considerably in size as compared to that noted by Dr. Anderson, at which time it was said to be about the size of an orange. The head of the pancreas was definitely indurated and hard and contained numerous areas of calcification, as shown by his roentgenograms. When the head of the pancreas was cut through at the right hand margin of the portal vein and superior mesenteric vessels there were areas that were almost rock-like in consistency and evidently were the site of calcareous degeneration. The entire body and tail were hard and indurated. No large cyst was encountered. A total pancreatectomy was considered impossible in this case because of the difficulty of dissecting this indurated calcified tissue from the portal vein and superior mesenteric vessels. For this reason a zone about 2 cm. in width was left, covering the portal vein. All of the pancreas to the left of the portal vein, together with the tail of the pancreas and the spleen were removed. The prepyloric part of the stomach, the pylorus and duodenum and head of the pancreas to the right of the portal vein, the duodenojejunal junction and about 6 or 7 cm. of jejunum were removed, making a second specimen.

The T-tube, which had been used at the first operation in March, was still in place. For this reason the common duct was not dilated, but it could be identified by the presence of the T-tube and because it was considered unwise to break up the opening in the common duct by removing the tube at that time it was left in place and was used as a guide in getting through the common duct near its entrance into the posterior wall of the duodenum.

*Procedure:* The patient had had two previous right rectus vertical incisions and for this reason an oblique transverse incision above the umbilicus was used. This gave very good exposure and made it possible to do the splenectomy and removal of the tail of the pancreas much more readily than if a right rectus incision had been used. A considerable amount of time (almost an hour) was used to dissect the dense adhesions described above, by sharp dissection. The lesser sac was entered after ligating the vessels in the gastrocolic omentum up to the point of the hilus of the spleen. This made it possible to remove the spleen with the tail of the pancreas and because it was essential to control the branches of the splenic vessels to the pancreas the spleen was removed. The pancreas was then dissected to the junction of the splenic and superior mesenteric vessels. The inferior mesenteric joined the splenic near this point. The pancreas was cut through and its stump was covered over by interrupted mattress sutures of No. 1 Deknatel. The duodenojejunal junction was then identified and about 6 or 7 cm. beyond this point an incision in the mesentery of

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the jejunum was made and the vessels ligated, leaving a good supply to the lower jejunal limb which was made by dividing the jejunum at that point. The proximal part of the jejunum with the duodenojejunal angle was brought up through a rent in the mesocolon and this, together with the duodenum and head of the pancreas, was dissected up to the superior mesenteric vessels and the beginning of the portal vein. The stomach was cut through the prepyloric portion and the distal stump, together with the duodenum and severed head of the pancreas was then removed, after cutting through the common duct below the point where the T-tube was seen. Hemostasis was established. No dilated duct could be made out and the right hand stump of the pancreas was then closed with interrupted No. 1 Deknatel sutures. The distal segment of jejunum was then brought up through the rent in the mesentery. The mesenteric half of the cut end of the jejunum was then closed with an over-and-over stitch of silk and about 1 cm. of the remaining opening of the jejunum was then anastomosed to the cut-end of the common duct after uniting the serous coats with continuous C silk and the two stomas then united with a continuous over-and-over suture of No. 000 chromic on an atraumatic needle. The seroserosal suture was then resumed to the point of beginning and the mesenteric border of the cut-end, which had been closed, was then tacked to the gastrohepatic omentum with interrupted silk sutures. The stump of the stomach was then approximated to the jejunum. The two serous surfaces were united with continuous C silk. An opening in the jejunum corresponding in length to the cut-end of the stomach was made, hemostasis established, and the two openings united by means of No. 00 chromic on two atraumatic needles with an over-and-over stitch, beginning at the center of the two adjacent parallel cut-edges, locked at the angles and carried around to a point opposite the point of beginning. The seroserosal suture was then continued to the point of beginning. This completed the anastomosis.

The peritoneal toilet was completed. A large soft rubber tube, containing a small tube inside of it for suction purposes, was placed in Morrison's pouch for possible leakage and the wound was closed with far-and-near steel wire sutures, steel wire being used because of the possibility of pancreatic or jejunal leakage. The T-tube was left in the original position above this incision.

*Postoperative Course:* A stormy four days during which time he required plasma and blood transfusions. His temperature ranged from 101°-104°F. for nine days. From then on he improved steadily. Wounds healed well. He was able to overcome his desire for hypodermic medication. He was discharged on his 27th day. Before leaving, a fat tolerance test done for three days on a measured fat intake and output showed that he was digesting 87 per cent of his fat intake. He was relieved of his pain. He was given ten units of insulin a day for an elevated blood sugar.

He has been followed several times by visits to the hospital. Twenty months after operation, he is relieved of his epigastric pain; he has no glycosuria with 10-15 units of insulin. His stools are normal if he takes small doses of pancreatic extract. He is working regularly.

*CASE 4.*—Unit No. 762485: Admitted 1/26/45. I. S., age 26, colored, married, laundress, separated. Chief complaints: Epigastric pain and voluminous, frequent fatty stools for ten months. F.H. One of 15 children, married, separated. One child eight years old, Husband had chronic cough.

*Past:* System review negative. One year ago was in Harlem Hospital for severe abdominal pain. Diagnosis: "Ptomaine poisoning." Ten months ago she began to have severe crampy epigastric pain associated with frequent bulky, fatty stools. Has had loss of weight and strength. Recently she has had more severe epigastric pain radiating to her back.

*Physical Examination:* A thin, unintelligent colored woman. No jaundice. The examination of the lungs reveals no pathology. A soft blowing systolic murmur is heard at the apex, not transmitted. There is some tenderness across the upper abdomen

along the site of the pancreas. Examination of the rest of the abdomen, the pelvis and extremities is negative.

*Laboratory Studies:* Blood picture is normal. Urinalysis reveals no glucose or albumin. Serology negative for lues. Stools show bundles of fatty acid crystals. Duodenal bile drainage negative. Pancreatic function tests with 10 mg. mecholyl chloride reveal low amylase, very low protease, small amount of lipase. Serum amylase: normal. Glucose tolerance reveals a diabetic curve. Cholecystogram shows no evidence of a gallbladder shadow. Plain films of the abdomen show numerous shadows of varying size and calcium density that almost outline the pancreas. *Diagnosis:* Diffuse pancreatic lithiasis.

*Operation.*—2/3/45: Total pancreatectomy, pylorotomy, total duodenectomy, choledochojejunostomy, and gastrojejunostomy.

*Pathology:* The findings in this patient proved to be unusually interesting and corresponded fairly accurately to the roentgenologic studies which had been made, showing extensive calcification of all of the pancreas with areas that might well have been pancreatic calculi. When the abdomen was opened the gallbladder was found to be normal. There were no stones. It was normal in color and it emptied easily. The liver appeared to be normal. There was no evidence whatsoever of fatty degeneration. The pathology was all confined to the pancreas—and there was plenty of it. On exposing the pancreas through the gastrohepatic omentum the body and tail could be seen and palpated. There was an extensive cystic degeneration of the body and tail as well as of the head, and on palpating it there were numerous movable calculi, which gave the feel of a gallbladder containing numerous stones. The body of the pancreas was much larger than normal, probably due to the extensive cystic degeneration. The head was similarly involved; the tail probably less than the body and head. The head of the pancreas, however, showed an unciform process which surrounded the superior mesenteric vessels and made removal of the pancreas difficult. The common duct was not dilated and when it was cut through near the duodenum it was found that the cystic duct ran parallel to it so that, if the duct had been ligated and the gallbladder used as a by-pass, no bile would have been available for emptying into the gallbladder. Because the patient showed all of the evidences of pancreatic deficiency in the presence of fatty stools and because the patient had had fatty stools, it was decided to do a total pancreatectomy. The etiology of the pancreatic calcification seemed to be the result of a previous acute pancreatitis, for there were very numerous filmy adhesions throughout the peritoneum. In places there were sheets of very delicate membrane, resembling fetal membrane. One of these measured in extent the size of the patient's anterior abdominal wall. The lesser sac was obliterated and the only etiology for the calcification seemed to be an acute pancreatitis, the history of which the patient gave in one of her many inaccurate statements that she had been taken to Harlem Hospital a year ago with a diagnosis of acute ptomaine poisoning.

*Procedure:* A transverse incision was made through both recti and splitting the obliques. The pancreas was approached through the lesser sac where, because of the low position of the stomach, it was possible to free the tail of the pancreas and the body without apparent damage to the splenic artery and vein. After this was done it was decided to remove the duodenum because of the intimate blood supply between the pancreas and the duodenum, and this was carried out by first applying crushing clamps at the duodenojejunal angle, the first portion of the jejunum being drawn up into the right upper quadrant. The duodenum was severed and the distal end was closed with an over-and-over suture of No. 1 silk, followed by a burying suture of No. 1 silk. The duodenum was mobilized with the head of the pancreas, but there the unciform process was found and it was decided to sever the common duct, and after ligating the gastroduodenal vessels the antrum of the stomach was cut through near the pylorus and the body of the pancreas, together with the head, was then dissected away from the superior mesenteric vessels and the portal vein. This was a



difficult and trying dissection because there were numerous tributaries to the portal which had to be carefully ligated, but after the pancreas had been removed with the duodenum the superior mesenteric and the splenic could be easily seen. The inferior mesenteric was not identified. Hemostasis was satisfactory.

A loop of jejunum near the duodenojejunal angle was then brought up anterior to the colon and a choledochojejunostomy was done between the cut-end of the duct and the jejunum by means of a seroserosal suture, followed by an over-and-over No. 000 chromic suture of the duct to the small opening in the jejunum. The seroserosal suture was then resumed to the point of beginning. About 12 cm. distal to this anastomosis the stomach was anastomosed to the jejunum, end-to-side, using the same technic.

The pancreas having been removed, there was no danger of pancreatic fistula, and a soft rubber tube containing a smaller rubber tube inside of it was placed to Morrison's pouch to take care of leakage. Closure: Steel wire near-and-far sutures.

*Pathology Report—Gross:* The specimen consists of a small segment of the pyloric end of the stomach and all the duodenum, which, in the fresh state, measure together 10 cm. in length. In the curve of the duodenum and attached to it is a nodular, hard, irregular pancreatic head, measuring 6.5 cm. in greatest dimension. This is attached to the rest of the pancreas and the total length of the organ is 19 cm. Toward the tail there is an irregular thickening and at this site the diameter is 5.5 cm. In the fresh state, particularly in the body of the organ, the tissues feel soft and contain great numbers of calculi.

After fixation and opening the duodenum, it is seen that the pyloric ring is situated about 2 cm. from the inversion. The papilla is not clearly seen, but on opening the common duct along a probe, it appears that in clamping the duodenum the papilla has been included in the clamp. There was apparently a very low point of entry. The opening of the pancreatic duct cannot be made out. The pancreas is, therefore, sectioned. It is an effort to find this opening. The organ is everywhere pitted by large, irregular cavities containing calculi. A greatly dilated pancreatic duct is found which courses irregularly to the head of the organ and is blocked by calculi. These stones are white, heavily calcified, but markedly friable. No normal pancreatic tissue is recognized even in the extreme tip of the tail. Everywhere there are craters surrounded by dense scar tissue. Fixation—formalin.

*Microscopic:* Section through the head of the pancreas shows ducts with incomplete epithelial lining, greatly distended and containing calculi. Where these have been incompletely decalcified, calcium is seen in section. There is a little granular material about these calculi and occasionally a few polymorphonuclear leukocytes are present. The pancreas is represented outside these ducts by dense cicatricial tissue in which there are widely separated small islets and small ducts. These small ducts are likewise dilated. Remnants of pancreatic acini are seen in a few fibrotic lobules. There is not any significant inflammatory reaction except in the vicinity of the larger ducts, where there are scattered lymphocytes. This same picture is seen in the body of the pancreas and the dilatation of ducts extends to the tip of the tail. The islet tissue is scant throughout. There is no suggestion of carcinoma.

Section taken through the duodenum in the hope of demonstrating a remnant of common duct fails to do so. It shows some cystic dilatation of some of the crypts of the duodenal glands.

Section of the liver biopsy shows no cirrhosis and no cholangitis. Some of the cells are distended by what is probably glycogen.

Section of the peritoneal adhesions shows a membrane composed of an exceedingly thin layer of stroma in which there are only occasional connective cells and no recognizable blood vessels. A single layer of peritoneal cells, flattened, except for their bulging nuclei, constitutes the surface. Unfortunately, this tissue was not impregnated

fresh with silver, so the structure of the surface cells cannot be demonstrated. *Diagnosis:* Chronic pancreatitis. Pancreaticolithiasis. Peritoneal adhesions. Liver.

*Postoperative Course:* Immediate recovery excellent. Out of bed on fourth day. Sugar in blood and urine was controlled by varying amounts of insulin—30-60 units o.d. The patient was rather ignorant and uncoöperative but before leaving the hospital on the 34th day she had been taught the use of hypodermic for insulin therapy and urinalysis for glucose. The epigastric pain had been entirely relieved. Her stools every day or q. 2 days. Normal in color and amount.

7/24/45: Readmitted for study and because she had developed a cough. Requires now between 30-70 units of globin insulin, on a 300-70-75 diet. Stool studies on a measured fat intake and output over a three-day period show she has 76 per cent absorption. With three tablets of pancreatin after each meal, a later test showed she had absorbed 83 per cent of her fat intake.

Sputum examination reveals tubercle bacilli and roentgenograms of chest shows a cavity in right upper lobe.

The patient was transferred to the Sea View Hospital for tuberculosis. A note from the hospital dated February 20, 1946, one year after pancreatectomy, says: "The right hemithorax is narrowed in volume and suggests the presence of considerable fibrosis in the lung or pleura. The left lung is free of infiltrate. Sputum has been positive. Her diabetic condition is well-controlled by protamin zinc insulin 84 units. Since admission she has presented a personality problem. At times she refused to eat or take her insulin. She has refused to have her temperature taken and at times refused to waken when rounds are made. Her temperature is still fluctuating."

CASE 5.—Unit No. 784094: Admitted 4/21/45. Died 5/7/45. B. B., age 46, white, female, school teacher. Chief complaint: Severe epigastric pain—ten weeks. F.H.—Irrelevant. Past: Influenza 1919. Incision of perirectal abscess in 1940.

*Present:* She was in relatively good health until 11 weeks ago when she began having voluminous, foul putty-like stools. Ten weeks ago she developed a severe, gnawing epigastric pain radiating to her back, made worse by eating. She was explored in another hospital five weeks later. The surgeon found a remarkable pancreas, having the feel of a "bag of shot," and chocolate cyst of the left ovary. Appendectomy and left salpingo-oophorectomy was done. The epigastric pain persisted, increasing in severity. Nausea and vomiting appeared. She had lost 20 lbs. in two months.

*Physical Examination:* Temperature, pulse, blood pressure were normal. She appeared to be a thin middle aged woman evidently in severe abdominal pain. No jaundice. Lungs clear. Heart normal. The abdomen showed a midline scar. There was marked epigastric tenderness. No masses or viscera were felt.

*Laboratory Findings:* Blood count normal. Urinalysis: 1026, acid, albumin 2+. Glucose 4+. No ketone bodies. Blood sugar 106 mg. per cent. Serum amylase 32 units (Myers and Killian). Pancreatic function test (mecholy) shows striking deficiency of all three ferments. Plasma protein 7.1. Urea nitrogen normal. Serum CO<sub>2</sub> 54. vol. per cent. X-ray films of abdomen show extensive calcium shadows in all parts of the pancreas.

*Operation.*—4/24/45: Total pancreatectomy, total duodenectomy, pylorotomy, splenectomy. Antecolic choledochojejunostomy and gastrojejunostomy. Transverse incision.

*Surgical Pathology:* The only abnormality was in the pancreas. It was enlarged throughout, was of fibrous consistency except for cystic areas which contained many large and small calculi, giving the "bag of shot" feel noted by the surgeon at the first operation. The liver and gallbladder appeared normal in every respect. The common duct was not dilated.

*Pathologic Report: Gross:* The specimen consists of a large pancreas resected

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together with the pylorus of the stomach and all of the duodenum. An additional specimen consists of the spleen, removed separately, and a biopsy of the liver. The pancreas measures 16 cm. in length and 4.5 cm. in width across the body. The head is considerably injected, measuring 8 cm. from above downward and 5.5 cm. from side to side, 3 cm. in thickness. A large portion of this consists of an exaggerated uncinate process in which the groove for the portal vein is found, making it clear that the vein was almost entirely surrounded by pancreas. The segment of stomach and duodenum removed measures approximately 26 cm. in length. The distal portion of the duodenum is hemorrhagic and the serosal surface is torn, apparently from operative trauma. The common duct on the posterior aspect of the head measures about 5 mm. in diameter. There is no suggestion of bile-staining of the tissue. There is a prominent hard lymph node at the lower border of the uncinate process. Palpable through the organ, except at the extreme tip, there are large, grating, irregular calcareous masses. The spleen weighs 80 grams and except for rather deep indentations on the anterior border, is not unusual. The liver biopsy is too small for gross description. The lesion is fixed in Kaiserling before section. After 24 hours fixation the specimen was opened by bisecting the body and tail of the pancreas and making serial sections of the head. The common duct, which was not dilated, was also opened along its length and traced into the ampulla. It was seen that the ducts were blocked by large, irregular calcareous masses with surfaces like fine white coral. The ducts of Wirsung and Santorini enter together and are separated from the common duct. The duct of Wirsung is greatly dilated where it is filled with calculi, measuring as much as 1.5 cm. in diameter. It is dilated throughout the length of the specimen and tortuous. The cut-surface of the pancreas appears as a number of small round openings which are surrounded by dense fibrous tissue. No normal pancreas is recognizable. Fixation—Bouin.

*Analysis of the Calculi:* The calcareous material was powdered and dried in vacuum and then it dissolved in hydrochloric acid with the evolution of gas. There was some slight organic residue but most of the material went in solution. Analysis showed that there were 42.4 mg. of cholesterol in the 111 mg. of stone. This is practically the theoretic amount to be expected if one assumes that the material is pure calcium carbonate.

*Microscopic:* Section through the head shows numerous irregularly dilated ducts surrounded by a fairly heavy collar of connective tissue. Peripheral to this collar there are smaller dilated ducts and a considerable number of islets. No recognizable scinar cells are seen. Some of the structures interpreted as ducts might conceivably be atrophic acini. Section through the tail shows a similar picture but here there are a few structures which may be interpreted as pancreatic acini.

I have discussed these findings with Dr. Dorothy Andersen who says that they are, with the exception of the calculus formation, similar to the changes in congenital cystic fibrosis of the pancreas where the obstruction depends on plugging of the ducts with secretion, not calculi. The reason for the calculus formation is obscure. This is not calcification of the pancreas on the basis of the previous inflammation but it is cystic fibrosis following obstruction. *Pathologic Diagnosis:* Pancreaticolithiasis. Fibrosis of pancreas.

*Postoperative Course:* The temperature rose from normal to 103°F. and remained elevated until a terminal 105°F. On the first day the shock was controlled by parenteral fluids and transfusion. Plasma proteins fell to 4.4, however, in spite of additional plasma and blood. Insulin 50-90 units failed to control the glycosuria. There was no ketonuria. On the fourth day she went into shock again but this was controlled by transfusion. Because of the large amount of gastric Levine tube drainage, a high ileus was suspected. She was reexplored. Some distention of the jejunal loop with edema was found. An anterior gastrojejunostomy was done. The patient went into severe shock, developed a pulmonary edema and died on the seventh day after her pancreatectomy.

*Autopsy:* The essential findings were a localized fibrinous bile peritonitis about the choledochojejunostomy, with edema of the stoma obstructing the flow of bile into the jejunum. A large branch of the portal vein was filled by an organizing thrombus and there were thrombi in some of the intrahepatic branches. The proximal loop of the jejunum was edematous but not obstructed. Sections of the liver showed areas of central focal necrosis. The gallbladder shows edema and early acute cholecystitis.

## REFERENCES

- <sup>1</sup> Priestley, J. T., Comfort, M. W., and Radcliffe, James Jr.: Total Pancreatectomy for Hyperinsulinism. *ANNALS OF SURGERY*, **119**, 211-221, 1944.
- <sup>2</sup> Claggett, O. T., *et al.*: Total Pancreatectomy; A Symposium Presenting Four Successful Cases, with Metabolic Studies. *Proc. Staff Mayo Clinic*, **21**, 25-46, 1946.
- <sup>3</sup> King, A. B., and Waghelstein, J. M.: Calcification of the Pancreas. *Arch. Int. Med.*, **69**, 165-176, 1942.
- <sup>4</sup> Lionello, J., Ficarra, B. J., and Ryan, N. H.: Pancreatic Calculi. *Arch. Surg.*, **48**, 137-143, 1944.
- <sup>5</sup> Rockey, E. W.: Total Pancreatectomy for Carcinoma. *ANNALS OF SURGERY*, **118**, 603-611, 1943.
- <sup>6</sup> Goldner, M. G., and Clark, D. E.: The Insulin Requirement of Man after Total Pancreatectomy. *J. Clin. Endocrin.*, **4**, 194-197, 1944.
- <sup>7</sup> Fallis, L. quoted by McClure, R. D.: Discussion. *ANNALS OF SURGERY*, **120**, 416, 1944.
- <sup>8</sup> Brunschwig, A., Ricketts, H. T., and Bigelow, R. R.: Total Pancreatectomy with Recovery. *Surg. Gyn. and Obstet.* **80**: 252-256, 1945.
- <sup>9</sup> Zininger, M. M.: Personal communication. 1945.
- <sup>10</sup> Brunschwig, A.: Surgical Treatment of Carcinoma of the Body of the Pancreas. *ANNALS OF SURGERY*, **120**, 406-416, 1944.
- <sup>11</sup> Brunschwig, A.: Personal communication, 1946.

**DISCUSSION.**—DR. RICHARD B. CATTELL, Boston, Mass.: We have had three patients with diffuse calculi and calcification of the pancreas, none of whom have been operated upon. I wish to call attention to the probable cause of pain in these cases and a possible means of relief without extensive resections. We have been able to relieve pain in cases of inoperable carcinoma of the pancreas with obstruction of the duct of Wirsung by anastomosing the duct of Wirsung to a defunctionalized loop of jejunum. This is not a difficult technical procedure and we have performed it in nine cases. After division of the gastrocolic omentum, a long antecolic loop of jejunum is brought up and anastomosed to the duct in the midportion of the body of the pancreas over a T-tube. It is quite possible that the same procedure could be utilized in calculous disease of the pancreas, although it would have no effect on the diffuse calcification. I suggest it as a possible means of relieving pain by a less radical procedure than total pancreatectomy.

DR. REGINALD H. SMITHWICK, Boston, Mass.: I hesitate to comment upon Doctor Whipple's presentation because my experience with this problem is confined to one case, because a different form of treatment was employed, and because the follow-up of the case to which I refer is of very short duration, six months.

This patient was a female in her early 50's and for some months she had been suffering from frequent excruciating attacks of deep-seated midepigastric pain, occurring principally at night and requiring large amounts of morphine for relief. She had calcification of the head of the pancreas. She had had a previous cholecystectomy. She was thought to have a duodenal ulcer also. She had severe diabetes and hypertension of moderate severity, associated with considerable evidence of cardiovascular damage.



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Because of her general condition, Doctor Allen, whose patient this woman was, and I were a little hesitant about resection of the pancreas in this particular case. Also, while we presumed that the pain was arising from intermittent distension of the pancreatic ducts, study of other possible visceral pain pathways by balloon distension of the lower esophagus, various portions of the duodenum and the upper jejunum, indicated that the same identical pain could be reproduced by stretching of any of these areas. This made us feel that this particular patient might continue to have attacks of abdominal pain following resection of the pancreas—as we have known it to recur after operations upon the biliary tract in particular.

We decided to section the viscerosensory pathways of the pancreas, the upper gastro-intestinal tract, and the lower esophagus. This was accomplished by transthoracic resection of the sympathetic trunk on the right side from D-3 to D-12, inclusive, and the great splanchnic nerve from the celiac ganglion to the midthoracic level. Since the pain was in the midline, we had expected that a bilateral procedure would be necessary, but so far there has been no recurrence of the pain.

Doctor Whipple's operation is a direct approach to the pathologic process and is, consequently, more logical. In general, the sectioning of viscerosensory pathways for the relief of abdominal pain of visceral origin should be employed as a last, not as a first resort. I mention this case simply to call attention to a possible alternative to resection of the pancreas, which may prove to be worth considering particularly in poor risks or complicated cases.

DR. ALEXANDER BRUNSCHWIG, Chicago, Ill.: I think the cases Doctor Whipple presents show a new indication for total pancreatectomy. I have not had occasion to perform this for chronic pancreatitis, but only for carcinoma. I have seen patients with extensive calcification in the pancreas and severe pain, who received exploratory celiotomy elsewhere and, because of firmness and enlargement of the pancreas the diagnosis of carcinoma was made. Morphine was not withheld but was given freely and they had become confirmed addicts.

On the other hand, we have seen patients who present almost no symptoms, certainly not enough to warrant any procedure on the pancreas, and yet roentgenograms showed extensive pancreatic calcification. Why the difference in symptomatology with apparently the same pathology? This is well worth further study. One other point; in two patients who had undergone total pancreatectomy there was postoperative insulin sensitivity. We had felt that large doses of insulin would be necessary but this did not prove to be the case. In one instance, ten units of insulin produced marked hypoglycemia. One does not have to be concerned immediately after operation with supplying insulin; in fact, it is better not to give insulin and become concerned only if and when diacetic acid and acetone appear in the urine.

I should like to hear Doctor Whipple's comments on the stools in his patients. In one patient who had had total gastrectomy as well as total pancreatectomy because of carcinoma, there was no change in the characteristics of the stool. Curiously enough, this patient had had diarrhea for some months before he was admitted for operation. It was semisolid, greenish-yellow and at times frothy. Total pancreatectomy, total duodenectomy and total gastrectomy did not result in change in the character of these stools. The patient succumbed three or four months later of carcinomatosis, and necropsy failed to reveal the cause of the diarrhea.

DR. M. M. ZINNINGER, Cincinnati, Ohio: With reference to the patient upon whom I operated, of whom Doctor Whipple showed the roentgenograms; I observed that man for about three years roentgenologically, and saw progressive increase in calcification and progressive increase in the amount of pain. The pain was at the level of the twelfth rib posteriorly, and for the last three months before operation he was relieved only with 0.5 gr. morphine. Examination of the specimen showed calcification not only in the substance of the pancreas but also in the duct, which was blocked at



more than one level; for that reason drainage of the duct would not have been of any value. We have seen six other cases with calcification of the head of the pancreas in which there was no pain. I believe that the pain must come from blockage of the duct, but simple removal of one stone in this case would not have relieved it.

DR. ALLEN O. WHIPPLE, New York City (closing): I appreciate Doctor Smithwick's presenting the case he reported. I intended to speak of that but I was pressed for time. I think the method he advises is one to be considered. It carries less risk than total pancreatectomy, and further studies should be made in that line.

With regard to Doctor Brunschwig's discussion, we have had a considerable variation in the condition of patients so far as fat tolerance is concerned, and the character of the stools, but at least three out of five that have been having trouble with the stools were relieved after operation, and in three patients where the fat intake and fat output was measured over three days, it showed that they absorbed all the way from 74 to 96 per cent of the fat ingested.

Two other things are difficult to explain. Some cases with extensive calcification had no pain, whereas others have intolerable pain; the other thing is the insulin requirement after total pancreatectomy. Some require little at first and later on require increasing amounts. This is a matter for further study as cases are reported.

## PANCREATITIS AS A CAUSE OF COMPLETE OBSTRUCTION OF THE COMMON DUCT\*

J. DEWEY BISGARD, M.D.

OMAHA, NEB.

THE PANCREAS has presented a challenge which has fascinated surgeons and physiologists for more than a century. This challenge, with a sense of frustration, was expressed by Pepper, in 1882, in the words: "It is unfortunate to have much to say, and yet to have no intelligible language in which to express it. This is somewhat the lot of the pancreas." Since that time the gland has become quite articulate but little has been gained in our knowledge of its inflammatory lesions.

The lack of a definitive method of establishing a diagnosis of chronic pancreatitis *in vivo* makes the problem of its relation to obstructive jaundice somewhat speculative. This uncertainty was stated by Moynihan as follows: "It is difficult to be dogmatic about the cause of obstruction (obstructive jaundice). History may be misleading, tests are at best uncertain, and even the final court of appeals, a celiotomy, may leave the position undecided. In the presence of so much uncertainty it is likely that operation will continue to be practiced; and if so, it seems reasonable that having ventured so far an attempt should be made to give relief."

In the majority of individuals (about 62 per cent) the distal end of the common duct is surrounded by pancreatic tissue and it is probable that inflammatory swelling of the encircling pancreatic tissue could cause compression of the duct or involve it in the inflammatory process in such a way as to produce obstruction. Unfortunately, it is impossible to prove this hypothesis. Pancreatitis is seldom if ever an isolated lesion, usually there is associated disease of the biliary system and never is it possible to be certain that other more common and tangible causes of obstruction have not been overlooked. For example, there always exists the irrefutable possibility that an obstructing gallstone has passed spontaneously or has been forced imperceptibly through the ampulla into the duodenum during palpation or instrumentation of the duct.

The literature dealing with this subject is indeed meager. There are several references to chronic pancreatitis in discussions which enumerate all possible causes of obstructive jaundice and some reports of cases in which the diagnosis was made solely upon the basis of operative findings and devoid of follow-up records of sufficient length to exclude an overlooked obstructing neoplasm.

In 1900, Mayo Robson reported 16 cases of jaundice associated with

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chronic pancreatitis as judged by palpation at operation. There was no other demonstrable cause of obstruction of the common duct but none of these cases had been followed longer than two years. In 1904, he reported 24 cases of which six were well from three to 14 years after operation. Two died soon after operation and both showed at postmortem examination a "cirrhotic condition" of the head of the pancreas with compression occlusion of the enclosed portion of the common duct. There were no evidences of neoplasm and no stones in the ducts.

Mikulicz, in 1903, reported a case, which at operation, he assumed to be a carcinoma of the head of the pancreas. The patient died ten days after operation and necropsy revealed the intrapancreatic portion of the common duct occluded by compression from what proved to be on section chronic inflammation of the pancreas. He recalled similar cases in which long periods of survival in good health following internal or surface drainage of the biliary system made it necessary to revise the operative diagnosis of carcinoma to that of pancreatitis.

Rowlands, in 1910, reported two likely cases but both were followed less than two years.

In 1932, Walters and Dehne reported 113 cases operated upon for jaundice which resulted presumably from obstructing lesions in the pancreas. Of those that survived operation, two were well 13 years later, one, nine years, and two, eight years. In these cases it seemed reasonable to assume that the obstruction had resulted from inflammation of the pancreas. They reported also five cases in which postmortem examination revealed inflammatory lesions of the pancreas and no other demonstrable cause of the obstructive jaundice. In a later publication Walters related that he had encountered cases of ulcer of the posterior wall of the duodenum which had perforated into the pancreas and the associated inflammation had caused obstruction of the common duct.

In 1937, Frazier was asked by the Council of the Association of Surgeons to investigate and report: "The End-results of the Surgical Treatment of Obstructive Jaundice in Relation to Pancreatic Disease." To obtain adequate material for this study, he circulated a questionnaire to all leading British surgeons and 172 responded, providing a pooled experience with 1,035 cases. Of this series, obstructive jaundice resulted presumably from chronic pancreatitis in 238 cases. The diagnosis of chronic pancreatitis was based upon either autopsy findings or impressions from observations at operation plus a sufficient survival period to exclude an overlooked obstructing carcinoma. One hundred seventy-two cases had satisfactory follow-up records, and 135, or 80 per cent, were living and well from one to ten years following operation. One hundred forty-four were treated by internal drainage and 53 by surface drainage.

It is interesting that in 88 per cent of the cases with malignant disease the gallbladder was much enlarged and tense, whereas in 85 per cent of cases

classified as chronic pancreatitis the gallbladder was thick-walled and usually contracted with and without stones. Furthermore, it was noted that pancreatitis occurred in a much younger group and that the jaundice was less intense and came on with less antecedent symptoms than carcinoma.

Carter and Hotz reported six cases, five of which had no follow-up records but in two of these biopsies were obtained from the pancreas at operation and both showed microscopic evidence of chronic inflammation. In one case necropsy revealed conclusive evidence of chronic pancreatitis constricting the common duct.

It is the purpose of this paper to report two cases of obstructive jaundice in which an existing pancreatitis, as judged by operative findings and blood amylase studies, was the only demonstrable cause of obstruction of the common duct. In both cases the common and the hepatic ducts were dilated, in one, only moderately, in the other, enormously, and in both the bile in the ducts was thick and slightly muddy and in one under pressure. The head of the pancreas in both cases was much larger than normal, nodular, firm and tense. Intraductal investigation revealed no gallstones or other source of obstruction. After some hesitation from resistance small sounds passed into the duodenum. In both cases the gallbladder was much smaller than normal, contracted, thick-walled and contained no stones, and in both it contained bile not unlike that present in the ducts. The liver function studies in both cases were consistent with extrahepatic type of jaundice and the blood amylase was elevated to levels which reflect pancreatic disease.

Further evidence in support of the hypothesis is found in the fact that both cases recovered following prolonged drainage of the common duct.

One case has remained well and free from jaundice, now three years following operation. This fact is important principally in dispelling the possibility of a neoplasm as the cause of obstruction. The other case was well and free from jaundice for seven months. He then developed an intense jaundice and died in five days of an acute hepatitis. In this case a preoperative diagnosis of malignant disease had seemed a certainty, but the postmortem examination excluded this possibility.

The most convincing evidence in support of the hypothesis was revealed in the postoperative choledochograms (Figs. 1, 2 and 3). In both cases the common duct and hepatic ducts filled completely and without filling defects except in the distal portion of the common duct, where there appeared to be a tapered uniform constriction through which the radiopaque solution passed freely in one case and only when placed under pressure in the other one. Subsequent serial choledochograms (Fig. 2) were made in one case and these show a progressive increase in the filling of the constricted portion of the duct, interpreted as evidence of dilatation from release of constriction.

Furthermore, it should be emphasized that jaundice developed in the one case in the absence of real pain and in the other in the absence of colic but with pain which was relieved by antacid medication.

FIG. 1-A



1-B



FIG. 2-A



2-B

FIG. 1.—Case 1: Cholangiograms ten days after operation showing absence of filling of the distal intrapancreatic portion of the common duct with wide dilatation of the duct proximal to this point. The radiopaque solution passed into the duodenum, indicating incomplete obstruction.

Film B made 30 minutes after film A shows retention of much of the solution, indicative of partial obstruction. Note filling of the distal portion of the pancreatic duct.

FIG. 2.—Case 1: Cholangiograms 26 and 60 days after operation showing a progressive increase in the extent of filling of the intrapancreatic portion of the common duct, interpreted as release of inflammatory constriction. Note outline of ampulla and junction with pancreatic duct.



## PANCREATITIS

### CASE REPORTS

CASE 1.—V. H., No. 78224, a married housewife, of 34 years, was admitted to the University Hospital, April 13, 1943, complaining of jaundice, generalized pruritis, weakness, anorexia, some epigastric pain and weight-loss of 27 pounds in four months.

During the last three months of her last pregnancy, nine months ago, she had frequent attacks of moderately severe pain in the epigastrium extending around the left costal margin into the back. These attacks came once or twice a week and lasted a few hours. A white liquid oral medication gave relief. Following childbirth, six months prior to admission, these attacks became more frequent.

Two months ago she had several teeth extracted under local anesthesia and on the following day it was noticed by her doctor that she was jaundiced. A few days later she suffered moderately severe pain for three days, again, relieved by a white chalky liquid. Since then she has had no pain but has been deeply jaundiced and has suffered from generalized pruritis. The stools have been clay-colored and the urine dark. Her appetite has been poor and she has lost 27 pounds in four months.

The family and past histories were essentially negative.

Examination revealed a young, intensely jaundiced woman with diffuse excoriations of the skin from scratching. A smooth liver-edge which was only slightly tender was palpable 5 cm. below the costal margin. The laboratory studies on admission were as follows: Blood Kline and Kahn negative; Hb. 11 Gm.; R.B.C. 3,770,000; W.B.C. 5,900, with segs. 56, staffs 7, eosinophils 2, lymphocytes 29 and monocytes 5; prothrombin time 24.6 sec. (control 22.2 sec.); icterus index 165; sedimentation rate 47 mm., in one hour; Blood N.P.N. 21.2 mg., hippuric acid 2.3 Gm. excreted as benzoic acid in four hours, serum cholesterol 412 mg. per cent; serum inorganic phosphate 3.4 mg. per cent; phosphatase 5.1 units per 100 cc. of serum; quantitative urobilinogen too weak to match; cephalin flocculation negative; galactose tolerance negative on all specimens during four-hour period; blood amylase 480 units; gastric analysis, with histamine, no free and total acids, four and six; urine, negative except for bile; stools grey (clay-colored).

Roentgenographic studies showed shadows of an enlarged liver and spleen, an indentation of the lesser curvature at the cardia and pylorospasm.

A few days after admission the patient developed thrombophlebitis of the left leg, delaying exploratory operation for three weeks. During this interval the icterus index dropped from 165 to 28, the jaundice diminished perceptibly and bile appeared in the stools for about six days. But during the week prior to operation the stools again became acholic and the icterus index rose to 81.

Exploratory operation was performed just one month after admission. Both lobes of the liver were swollen and the surfaces had a mottled nutmeg appearance. The gallbladder was contracted down to the size of an olive, and its wall was very thick and pale. It contained no stones. The hepatic and common ducts were enormously dilated and the head of the pancreas was at least twice normal size, nodular, firm and fixed. The pancreas was exposed and tissue removed from its surface for frozen section which was reported normal pancreatic tissue.

The common duct was then opened and explored. There escaped considerable thick muddy bile under tension and similar bile was expressed from the gallbladder. A thorough search of the common and hepatic ducts with grasping forceps, scoop and irrigation produced no stones. A small common duct sound passed with some resistance through the sphincter of Oddi into the duodenum.

The opening into the common duct was closed around a T-tube which was brought to the surface through a stab wound. A cigarette drain placed in the lumbar gutter was likewise exteriorized through a stab wound and the abdomen closed.

Since the cause of the obstruction of the common duct was not definitely determined the gallbladder was left *in situ*, for use in anastomosis to the gastro-intestinal tract if a by-pass subsequently became necessary.

Convalescence from operation was uneventful and the jaundice rapidly faded with the icterus index receding to 15 by the end of three weeks. Unfortunately, only the admission determination of blood amylase was obtained.

Choledochographic studies were made on the tenth, 25th and 60th postoperative days (See Figs. 1 and 2). The first choledochograms were interpreted as follows:

"The distal 2 cm. of the common duct show a definite narrowing or constriction. The common duct is dilated proximally up to 2 cm. Diodrast passed into the duodenum and showed a reflux into the pancreatic duct. *Impression:* Constriction of common duct distally and dilatation proximally, which may be associated with pancreatic disease."

The two subsequent studies were interpreted as showing no change except for increased filling of the constricted distal 2 cm. of the common duct.

The T-tube was removed July 9, 1943 approximately nine weeks after operation and after 24 hours no bile drained from the sinus.

The patient has remained well and there has been no return of jaundice in nearly three years.

CASE 2.—No. 162451: J.M., an intensely jaundiced man, age 71, entered the Nebraska Methodist Hospital, July 28, 1945, complaining of weakness, loss of appetite, nausea, epigastric distress described as bloat and burning, jaundice and generalized pruritis of three weeks duration.

Six months previously he had been disabled for a few weeks from contusions inflicted in an automobile accident. He denied having taken any drugs at that time or subsequently.

For one year he had frequently been distressed with a burning sensation and belching following meals which were rich in fats. There had been no other symptoms referable to gallbladder disease until three weeks before admission. At that time the burning sensation which had been confined previously to the epigastrium extended into the right hypochondrium and into the back and at the onset was accompanied by nausea and vomiting. On the following day his physician observed that he was jaundiced. Subsequently, as the jaundice increased, there developed pruritis, soft clay-colored stools, weakness, loss of appetite and some loss of weight. At no time had he suffered definite pain.

Examination revealed in addition to an intense jaundice with diffuse excoriations of the skin, moderate arteriosclerosis, bradycardia, an hypertension of 160/90 and a smooth slightly tender liver margin about 3 cm. below the costal margin with a mesial rounded mass which was assumed to be a distended gallbladder.

On admission, the urine contained much bile and a trace of albumin; the blood, Hb. 97 per cent, R.B.C. 5,050,000; W.B.C. 11,300, with a normal differential. The blood Kahn, Kline and Mazzini were negative. The prothrombin time was 36 seconds with a normal standard of 12–14 seconds; the icterus index 240 units and the blood amylase 530 units. The stools contained no bile.

A plain roentgenogram of the abdomen revealed no evidence of stones and was negative except for vertebral osteo-arthritis.

A provisional diagnosis of carcinoma of the head of the pancreas or of the ampulla of Vater was made and the patient prepared for operation with parenteral glucose and maximum therapeutic doses of vitamins B complex, C and K. The prothrombin time dropped to 28 seconds.

The cephalin flocculation and galactose tolerance tests done on the day prior to operation were negative.

Operation revealed the liver symmetrically and much enlarged, with a pale mottled appearance. The gallbladder was contracted to the size of a large olive and its wall was very thick. The mass palpated and interpreted preoperatively as an enlarged gallbladder was probably the enlarged left lobe of the liver. The common duct was not much enlarged but had a thick wall and was enclosed in dense fibrous tissue; no

stones or other abnormalities were palpated in it. The head and a portion of the body of the pancreas were definitely enlarged, firm and nodular but no discrete hard masses were palpable. The common duct was opened and a surprisingly small quantity of thick bile escaped. A small amount of similar bile was expressed from the gallbladder. No stones were found in the ducts despite painstaking search with forceps, scoop and lavage. A small sound was passed into the duodenum and the ampulla of Vater felt normal as palpated over the sound.

The opening in the common duct was sutured around a T-tube which was delivered to the surface. Through a stab wound a cigarette drain was placed in Morison's pouch and the abdomen closed.

Because the ducts were only moderately dilated and because there was not a large pool of dammed-back bile to escape upon opening the common duct it was my impression that the patient had a toxic hepatitis or some other intrahepatic type of icterus. However, apprehension in this regard was dispelled by the uninterrupted excretion of bile and the uneventful convalescence.

During the first 24 hours 275 cc. of bile drained through the T-tube and subsequently the daily output varied from 350 cc. to 500 cc. There was a rapid dissipation of the icterus and the patient left the hospital 22 days after operation. At that time the icterus index had dropped from the preoperative level of 240 to 22 units. The blood amylase which rose to 920 units on the second day after operation was still 760 units on the 18th day. These unusual blood amylase findings are reported with reservations regarding accuracy but in prospect of similar findings in similar cases.

Cholangiograms made on the 11th day following operation (Fig. 3) showed that the major portion of the injected iodized oil passed directly into the duodenum with evidence of very little obstruction and no filling defect. The distal common duct failed to fill and there was some retention after 30 minutes.

The T-tube was clamped when the patient left the hospital. Three weeks later his family physician reported that there had been no recurrence of jaundice and upon instruction removed the tube.

The patient remained well and there was no recurrence of jaundice for seven months. He then developed an upper respiratory infection for which he took some "cold tablets."

A few days later he developed jaundice, nausea and acholic stools and after five days entered the hospital intensely jaundiced, with a moderate ascites and in stupor. Before death ensued, 18 hours later, the hippuric acid and cephalin flocculation tests indicated liver failure. The icterus index was 100 units, the prothrombin time 48.5 (control 22) seconds, and the serum amylase 103 units.

The postmortem examination revealed about four liters of bile-stained ascitic fluid, a very small pale yellow liver (820 Gm.) which on section showed necrosis and extensive loss of liver cells with fibrous and fatty replacement. The common bile duct



FIG. 3.—Case 2: Cholangiogram 11 days after operation and 30 minutes after injection of the radiopaque solution. Note lack of filling of the distal end of the common duct with a small quantity of retained solution proximally.

was normally patent and normal in appearance. It contained no bile and there was no bile in the intrahepatic ductal system. The gallbladder was very small, contracted, thick-walled and contained no bile and no stones. The pancreas was normal except for some fibrosis in the portion of the head immediately underlying a deep posterior duodenal ulcer. There was also an ulcer on the anterior wall and the stomach and small bowel contained much blood which presumably was lost from one of the ulcers. The only additional pertinent finding was some areas of atelectasis and terminal pneumonia in both lungs.

There is unequivocal necropsy evidence that death and the brief terminal episode of jaundice resulted from hepatitis with degeneration of the liver to the point of failure. It was hoped that the necropsy would also establish the cause of the episode of jaundice and acholic stools which seven months previously was cured following drainage of the common duct. Unfortunately, the additional evidence is inconclusive and does not alter the original clinical impression. It dispelled all doubt of an overlooked source of obstruction of the common duct such as stone and neoplasm. The evidence argues strongly that both episodes represented failure of a damaged liver varying only in degree with a brief intervening period of regeneration and recovery. However, it seems inconceivable that a severely damaged liver not only would survive the insult of operation but also would immediately resume normal excretion of bile and rapidly recover, especially in an individual 71 years of age.

There was some postmortem evidence of a preëxisting pancreatitis, the source of which might be explained upon the basis of the overlying posterior duodenal ulcer.

**DISCUSSION.**—In making the diagnosis of chronic pancreatitis with obstructive jaundice it is assumed that (1) the jaundice is extrahepatic in origin; (2) chronic pancreatitis exists; and (3) the assumed inflammation of the pancreas is capable of obstructing the common duct. In the second case only is there any question that the jaundice was not extrahepatic. It seems probable that the liver damage which caused the second episode of jaundice and death had its origin in the hepatitis which accompanied the period of obstructive jaundice prior to operation seven months previously.

A diagnosis of chronic pancreatitis can be made with certainty only by histologic confirmation. In the living this may be accomplished by biopsy and such confirmation has been reported. A negative biopsy as in my case has no significance because the tissue removed from the surface may be remote from the inflammatory process. Furthermore, the information to be gained from an adequate biopsy does not justify the hazard involved.

The other two sources of information upon which a diagnosis is based are inconclusive. First, the impression of the surgeon as gained from palpation and inspection of the gland is valuable in proportion to the experience of the surgeon and is always subject to the error incident to the wide normal variation in the size and consistency of the pancreas.

The second source, an elevated serum amylase is suggestive if not indicative of inflammation of the pancreas. This has been abundantly investigated and



has been a fairly consistent clinical observation. Furthermore, studies have demonstrated rather consistently that serum amylase is relatively normal in cases of gall-bladder disease with no associated pancreatitis and is usually below normal in cases of hepatitis and other disease of the liver.

Foged, Millbourn, and Branch and Zollinger have found the serum amylase elevated in cases of obstruction of the common duct by a stone at the ampulla of Vater. Lewison suggested that in these cases the common and one of the pancreatic ducts have a common opening at the ampulla so that the stone also obstructs the pancreatic duct. He also observed that serum amylase in these cases is elevated only slightly in comparison with the high levels observed in cases of acute pancreatitis.

In both of my cases the serum amylase attained the high levels which are seldom seen except in cases of acute pancreatitis. For this reason their accuracy and value in these instances are open to question.

The third assumption that the inflamed pancreas in my cases obstructed the distal end of the common duct was suggested by the resistance encountered in passing a bougie. Choledochographic studies in these cases, as illustrated in Figures 1, 2 and 3, are offered as graphic evidence of constriction of the distal or intrapancreatic portion of the common duct.

#### CONCLUSIONS

1. Reported are two cases of relatively painless extrahepatic obstructive jaundice. In both cases there was chronic cholecystitis without stones, and much evidence to support a diagnosis of chronic pancreatitis. Both cases recovered following surface drainage of the common duct.

2. In both cases the postoperative choledochograms showed narrowing of the distal end of the common duct suggestive of compression from pancreatic disease. In one case subsequent choledochograms were made and these showed a progressive increase in the filling of the constricted portion of the duct, interpreted as evidence of release of compression.

3. From the evidence it is suggested that the obstruction of the common duct in these two cases probably was caused by chronic pancreatitis. The evidence is offered in support of the hypothesis that on occasion the swelling of chronic pancreatitis obstructs the intrapancreatic portion of the common duct.

#### REFERENCES

- <sup>1</sup> Branch, C. D., and Zollinger, L.: Value of Blood Diastase in Diagnosis of Common Duct Stone. *Am. J. Surg.*, **41**, 233, 1938.
- <sup>2</sup> Carter, R. F., and Hotz, R., Pancreatitis and Biliary Tract Disease. *Am. Jour. Surg.*, **44**, 719, 1939.
- <sup>3</sup> Frazier, J.: Surgical Treatment of Obstructive Jaundice in Pancreatic Disease. *Brit. Jour. Surg.*, **26**, 393, 1938.
- <sup>4</sup> Foged, J.: The Clinical Significance of Diastasuria. *Acta Chirug. Scand.*, **73**, 203, 1933.
- <sup>5</sup> Lewison, E. F.: The Clinical Value of Serum Amylase Test. *S. G. & O.*, **72**, 202, 1941.
- <sup>6</sup> Mayo Robson, A. W.: Pancreatitis: With Special Reference to Chronic Pancreatitis. *Lancet*, **2**, 235, 1900.



- <sup>7</sup> Mayo Robson, A. W.: The Pathology and Surgery of Certain Diseases of the Pancreas. *Lancet*, **1**, 733, 845, 911, 1904.
- <sup>8</sup> Mikulicz, V.: Surgery of the Pancreas. *ANNALS OF SURGERY*, **38**, 1, 1903.
- <sup>9</sup> Mikulicz, V.: Surgery of the Pancreas. *Trans. of Congress of Am. Phys. and Surg.*, **6**, 55, 1903.
- <sup>10</sup> Millbourn, E.: Diastasia Conditions in Cases of Jaundice due to Cholelithiasis, Acute Hepatitis, and Malignant Tumors. *Acta Chirug. Scand.*, **77**, 523, 1936.
- <sup>11</sup> Pepper, W.: Clinical Remarks on Several Cases of Pancreatic Disease. *Med. News*, **2**, 678, 1882.
- <sup>12</sup> Rowlands: Jaundice due to Chronic Pancreatitis. *Guy's Hosp. Gaz.*, **24**, 269, 1910.
- <sup>13</sup> Walters, W., and Dehne, E. A.: Jaundice caused by Pancreatic Lesions. *S. G. & O.*, **54**, 832, 1932.
- <sup>14</sup> Walters, W.: Bile Duct Obstruction. *Surgery*, **3**, 884, 1938.

DISCUSSION.—DR. RALPH COLP, New York City: I think the excellent result obtained in this patient following drainage of the common bile duct was due to the relief of the biliary reflux. The roentgenograms show the outline of part of the pancreatic duct and it is possible that the reflux of bile caused the pancreatitis. By relieving pressure by choledochostomy, a marked improvement took place. I recently had occasion to operate upon a patient who had a chronic infection of the gallbladder with stones and, following cholecystectomy, he began to develop attacks of jaundice. Sixteen months later, exploration revealed a marked dilatation of the common bile duct extending into the hepatic duct due to pancreatitis, and I performed choledochoduodenostomy over the tube. Six months later there were recurrent signs of obstructive jaundice of no great intensity, but he was febrile and I felt that reexploration was indicated. I found an enormous dilatation of the common bile duct, and the pancreas, previously hard and diffusely infiltrated, was still of the same consistency. There was no evidence of carcinoma. I performed a choledochoduodenostomy over the vitallium tube. I was able to pass a probe freely into the common bile duct at the first operation, but at the second operation it was not possible, even though the patient was only mildly jaundiced.

(slides) This shows the presence of the vitallium tube, the funnel part of which is in the common bile duct. This slide shows the marked dilatation of the duct with reflux of barium which had previously been given by mouth. You can see the pancreatic portion of the common bile duct outlined by a very thin stream of barium. I doubt very much whether a choledochostomy would have caused a reversal of the pancreatitis which was present in this case.

DR. JOHN J. MORTON, Rochester, N. Y.: I am a little surprised that Doctor Bisgard found elevated amylase so late in the disease. In the first week the pancreatic amylase will drop to normal if the patient is going to recover, and faster than that in the fulminating hemorrhagic type which destroys the pancreas. Sometimes there is a moderate infection present, and in these cases the amylase steps-up and you have to take out some of the pancreas as there will be a partial pancreatic necrosis. Chronic pancreatitis, according to the literature, is not accompanied by a rise in the blood amylase.

DR. I. S. RAVDIN, Philadelphia, Pa.: I am in hearty agreement with what Doctor Morton has just said. We have never seen elevation of blood amylase concentration such as Doctor Bisgard has reported in chronic pancreatitis. These have always been associated with acute inflammatory reaction. The choleo-angiograms are not unlike some of those I see where I have removed a stone from the lower end of the common duct. Doctor Prendergrass reports this as evidence of reaction in the pancreas, but not as chronic diffuse pancreatitis. In the last slide shown, the hepatic ducts were

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still clearly outlined, which means that the impediment to bile flow, whatever it may have been, still persisted. Finally, reflux into the pancreatic duct must be considered as evidence of continuing distal ductal obstruction. If there were no impediment of either the sphincter mechanism or in the ampulla, the pancreatic duct should not be visualized. If these patients did have pancreatitis it was still persisting, and I would not have interpreted the last films as evidence of marked improvement.

DR. J. DEWEY BISGARD, Omaha, Nebr. (closing): In reply to Doctors Colp, Morton, and Ravdin, I might say that I too questioned the validity of the high values of the blood amylase in these cases. The values in other cases have always been in line and usually normal values.

In one case the blood amylase went up to 920 units following operation and was still 760 units on the 18th postoperative day. This was added reason to be critical of the laboratory, but on their record I accepted the figures and recorded them in this report. Going through the literature, I found records of similar elevation of the blood amylase in cases in which the common duct was obstructed by a stone lodged at the ampulla. It was suggested that in these cases the stone also obstructed the pancreatic duct. In most cases of stone in the common duct, however, there is no appreciable rise in the blood amylase, and in liver disease there is an actual decrease.

The fact that the jaundice did clear in these two cases and remained so after the T-tubes were removed was evidence that whatever caused the obstructive jaundice had been released and, as stated in the paper, it is difficult or impossible to exclude some obstructing factor other than pancreatitis that might have been dislodged at operation. A roentgenologist, with a very wide experience in interpreting cholelithograms, interpreted the defect in the distal end of the common duct, in the films shown, as a defect caused by pancreatic disease. I routinely do postoperative cholelithograms on all cases in which I have opened the common duct, and I have yet to see a constriction of the distal two centimeters, or so, of the common duct as shown in these slides. I am rather surprised to hear Doctor Ravdin interpret this constriction as spasm of the common duct. To my knowledge the common duct contains no muscle and, without muscle, spasm is impossible.

## RESULTS FROM USING VITALLIUM TUBES IN BILIARY SURGERY\*

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ANY SURGEON who has treated extensive injury of the common bile duct is well aware of the tendency to recurrent stricture formation with jaundice, cholangitis, and liver damage. These strictures do not respond, as do some smaller ones, to dilatation, plastic repair, or excision with end-to-end anastomosis of the duct. Attempts to implant a biliary fistula failed. Anastomosis of the bile duct to the duodenum was done, but the results were poor, for in Eliot's<sup>8</sup> review of 68 cases, only 16 (23 per cent) were successful.

Badly damaged or excised bile ducts were repaired by end-to-end anastomosis over a Vitallium† tube, hoping in this way to preserve their continuity and to prevent reformation of the stricture. This was first done on February 26, 1940, the method was reported<sup>17, 18</sup> and the tubes were made available for the use of other surgeons. I was only interested in their design, so the manufacture, distribution, and sale were carried on by the Austenal Laboratories, makers of Vitallium, who have marketed the tubes through surgical instrument dealers. Thus, there was no way of my knowing who had used them and what the results had been. It was decided to write the members of the American Surgical Association, not only to seek their experience, but also to ask the names of any other surgeons that they might have known who had used the tubes. The response was very gratifying, for, with but few exceptions, replies were received and necessary data given in spite of the press of extra work both in civil and military life due to the war. I am very grateful for this.

The data received combined with that from personal experience allowed the study of 229 cases. Of these, 13 were excluded because they did not give the information pertinent to this study. In ten of these the patient died in the hospital soon after operation, and in three cases it was found that the tube had not been placed in the bile ducts.

### REPAIR OF THE COMMON BILE DUCT

There were 106 cases in which a Vitallium tube was used to repair a damaged or excised common bile duct. Some of these were very extensive injuries involving loss from just below the bifurcation of the hepatic ducts to just above the pancreas. The results are shown in Table I.

In such a serious condition often preceded by multiple operations where the best previous score was 23 per cent<sup>8</sup> this figure of 80.1 per cent good results is encouraging. It will be noted that one cause of failure was from bridging a gap with the tube by tying its ends into the ends of the bile duct. These

\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

† "The word Vitallium is a registered trade-mark of Austenal Laboratories, Inc."

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cases failed, for sooner or later the tube slipped. Bridging a gap is unnecessary, for even with wide separation it is possible to mobilize the duodenum and pancreas and suture the ends of the duct together over the tube. Final success depends upon accurate end-to-end anastomosis even if done under some tension. The tube holds this open and prevents stricture during healing.

TABLE I

RESULTS FROM USING A VITALLIUM TUBE IN 106 CASES OF REPAIR OF THE COMMON DUCT

Good.....	83 cases
Good, but tube passed.....	2 cases
Total—good results.....	85 cases—80.1%
Doubtful.....	1 case
Poor—tube plugged.....	12 cases—11.3%
Poor—bridged a gap.....	7 cases
Poor—tube slipped.....	1 case
Total.....	106 cases

The finding of poor results in 12 cases (11.3 per cent) due to plugging of the tube is more disturbing, for it is not so easily remedied. Many of these patients have infection which increases the tendency to deposition of sediment. I have had this material analyzed on three occasions through the coöperation of Drs. S. H. Bassett and H. E. VanAlstyne.

January 21, 1944	Lipids (cholesterol)	0.1664 Gm. (38%)
	Insoluble*	0.2655 Gm.
March 24, 1945	Lipids (cholesterol)	0.1619 Gm. (36%)
	Insoluble*	0.2881 Gm.
October 23, 1945	Lipids (cholesterol)	0.146 Gm. (56%)
	Insoluble*	0.114 Gm.

\* Only from 0.0015 Gm. to 0.0075 Gm. of calcium could be extracted from the insoluble fraction. The remainder appeared to be bile pigment.

This level (36 per cent-56 per cent) of cholesterol is disappointing for it is the only soluble constituent. It has been our custom to give sodium taurocholate at intervals postoperatively in the belief that the solubility of cholesterol was increased. Sodium dehydrocholate also does this, but ox bile (U.S.P. 45 per cent cholic acid) is not so effective.

My personal experience with plugging of the tube has turned out fortunately, for information of value has been obtained. It was found that there had been restoration of normal mucosa, appearance and caliber, so the plugged tubes were removed and the ducts closed.

## CASE REPORTS

Case 1.—No. 171848: E. H., a 54-year-old diabetic female. First operation elsewhere, May 22, 1940, for acute cholecystitis. Jaundice, chills, and fever developed in three months. Second operation, May 20, 1941, dilatation of stricture of bile duct and removal of stones. Jaundice returned in three months. Third operation, October 1, 1941, I found a

stricture of the common hepatic duct about 1.5 cm. long that was "so dense that the smallest probe had to be forced through it." Stricture excised and duct sutured over a Vitallium tube with relief for over two years, when jaundice returned. Fourth operation, December 24, 1943. The plugged Vitallium tube was removed. "To the operator's amazement, it was found that the duct would admit a No. 18 catheter easily, and that the lining of the duct was smooth, velvety mucosa which was perfectly normal in appearance." The opening in the duct was closed and uneventful recovery followed. Last follow-up on January 31, 1946 (25 months postoperatively) "The patient's condition is excellent."

Case 2.—No. 186570: A. B., a 33-year-old female had a cholecystectomy elsewhere, November 11, 1941, at which time hemorrhage occurred and the bile duct was opened. It was drained. She had attacks of pain and jaundice after operation. At the second operation, January 22, 1942, the hepatic duct, just below the bifurcation, entered an extrabiliary cavity that connected with the stump of the common duct which was present for one-half-inch above the pancreas. These ducts were freshened and sutured end-to-end over a Vitallium tube. Her condition was satisfactory until August, 1945, when pain and jaundice returned. The third operation was done, October 10, 1945, to remove a plugged Vitallium tube. The site of the anastomosis was covered with mucosa and admitted a 7-mm. dilator so the opening in the duct was sutured and a cigarette drain was placed in the subhepatic space. One episode of upper abdominal pain without jaundice occurred two months postoperatively, the cause of which was not determined. Since then she has remained well.

This is a very encouraging result, for if a severely damaged duct will reconstitute a normal caliber and mucosa, it will not matter if some tubes plug. They will have served their purpose.

The most trying technical problem in the secondary repair of a severed duct is to find the lower end after it has retracted and become buried in scar tissue. Lahey<sup>11</sup> has described a method of doing this by mobilizing the duodenum and locating the lower end of the common duct on the undersurface of the pancreas. This maneuver permitted identification of the duct in one of my cases. In all the others it could not be found in this way and was only located by careful, patient dissection in the scar just above the duodenum. But dissection in this region may jeopardize the portal vein, and in two cases I have entered this vessel, fortunately with successful suture in each.

In the hope of getting more exact information on how to locate the distal end of the duct, 18 cadavers were dissected, with the assistance of Dr. C. E. Tobin, of the Department of Anatomy. In all 18 subjects the lower end of the common duct was imbedded in the pancreas so it could not be identified by looking on the undersurface of that organ. Measurements were taken from the pylorus to the opening of the common bile duct into the duodenum. These ranged from 6.5 cm. to 12 cm. with an average of 8.5 cm., so one cannot locate the duodenal end by measurement. The papilla of Vater was present in ten, small in five, and absent in three. The mucosal fold indicating the papilla was normal in 14, small in two, and absent in two. So by opening the duodenum one is not certain of being able to locate the duct, and may incur the danger of a duodenal fistula.

At the present time a combination of these methods is used. All adhesions are freed from the right lobe of the liver, and the relationship of the duodenum to the foramen of Winslow is restored. The hepatic duct is located. If the



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lower end of the duct is not seen, it is searched for in the scar of the gastro-hepatic omentum near the upper border of the duodenum. This relationship with the duodenum at about the junction of the first and second portion is a fairly constant one. If these efforts fail, the duodenum is mobilized and the posterior surface of the pancreas inspected. If the duct is not found either the duodenum is opened or the search is abandoned and the upper part of the duct is anastomosed to the jejunum.

### HEPATICODUODENOSTOMY

The operation of anastomosis of the hepatic or common bile duct to the duodenum, as it was described by Mayo,<sup>15</sup> was probably the most commonly used procedure in this field. It has the two serious disadvantages of allowing reflux of food into the biliary passages, and a tendency to stricture at the site of union. As a consequence, the majority (77 per cent) of the patients have trouble from cholangitis or biliary obstruction. One personal case (No. 227212) has had 16 hospital admissions and ten operations, many as a result of an hepaticoduodenostomy. She was immediately relieved after this was disconnected and the common bile duct was reconstituted over a Vitallium tube. Neither in this case, nor in any other, has disuse atrophy of the functionless distal end of the common duct been found, as reported by Allen.<sup>1</sup>

There are reports of 79 cases in which a Vitallium tube was used in doing an hepaticoduodenostomy. The results are given in Table II.

TABLE II

#### RESULTS IN 79 CASES OF HEPATICODUODENOSTOMY DONE WITH A VITALLIUM TUBE

Good.....	43 cases
Good, but tube passed.....	3 cases
Total good results.....	46 cases—58.2%
Doubtful.....	1 case
Poor—tube passed.....	27 cases—34.1%
Poor—tube plugged.....	4 cases
Poor—fatal hemorrhage from tube.....	1 case
Total.....	79 cases

If the three satisfactory cases in which the tube passed are added to the 27 poor results in which it passed, it is seen that in 30 cases (38 per cent) the tube is known to have passed into the gastro-intestinal tract. It is probable that, in the end, the majority will pass, for there is little to prevent it. Certainly, the flange in the center is not enough, nor are sutures, for all past experience indicates that any foreign body that protrudes into the bowel will eventually be passed.

These Vitallium tubes were never designed for hepaticoduodenostomy; in fact, they were designed to avoid it, and to retain the function of the sphincter of Oddi by reconstructing the bile duct. But soon after they were available surgeons used them in the duct-duodenal anastomosis, so this use was illustrated<sup>18</sup> in their description. Perhaps this was unwise, for it may have contributed somewhat to having 79 cases of this type to report here. Granted

that the operation is an expedient way out of a difficulty that may give brilliant immediate results, yet it is essentially unphysiologic. The use of the vitallium tube cannot alter this, for it can only prevent stricture of the anastomosis. Reflux and the threat of cholangitis will remain.

#### HEPATICOJEJUNOSTOMY

As a general principle a bile duct without a sphincter should not be connected with a loop of intestine that conveys food, for sooner or later this will cause trouble. An antiperistaltic loop of jejunum fulfills this requirement. Antiperistalsis has been shown by Mall<sup>13</sup> to be capable of causing partial blockage of the intestinal current. It has been employed by Mann<sup>14</sup> to prevent leakage from intestinal fistulae. Whipple<sup>22</sup> used the Roux-Y-type of antiperistaltic loop of jejunum to anastomose to the biliary tract after resecting the head of the pancreas.

In this series there were 18 cases of hepaticojejunostomy done with a Vitallium tube, the results of which are shown in Table III.

TABLE III

RESULTS IN 18 CASES OF HEPATICOJEJUNOSTOMY DONE WITH A VITALLIUM TUBE

Roux-Y anastomosis—results good .....	8 cases
Loop with entero-anastomosis—results good .....	7 cases
Total .....	15 cases—83.3%
Loop with entero-anastomosis—results poor .....	3 cases
Total .....	18 cases
In seven cases (38.8%) the tube is known to have passed	

This group is too small to have any statistical significance, but the facts available would indicate that the results are superior to those in hepaticoduodenostomy, which is to be expected. These data also give preference to the Roux-Y-type of anastomosis. In this regard Cole<sup>5</sup> reports a case who after an hepaticojejunostomy by a loop with entero-anastomosis had severe cholangitis. He reasoned that food was being carried past the entero-anastomosis up the proximal loop to the bile duct. So he divided and closed this proximal loop, leaving essentially a Roux-Y anastomosis, with immediate relief of symptoms.

It might be argued that a Vitallium tube is not necessary in doing a bile duct-jejunal anastomosis. This is valid in cases where sufficient hepatic duct remains to do an exact approximation of the structures. However, Cole<sup>6</sup> feels that his results with the Vitallium tube are definitely superior to those without it. In some cases no mobile bile duct is available for anastomosis, and only a hole in the porta hepatis communicates with the biliary tract. Here the insertion of a tube materially helps in the anastomosis.

#### OTHER USES

There are three cases where the bile duct was anastomosed to the stomach by means of a tube, with satisfactory results to date. In two instances of

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severe chronic pancreatitis a long tube was passed into the duodenum. Both of these were relieved of their symptoms. Five cases of inoperable carcinoma were treated palliatively by using a Vitallium tube, with temporary relief of their biliary obstruction. The pancreatic duct was anastomosed to the intestine by means of a tube in three cases, with satisfactory results.

### SUMMARY

A group of 229 cases were collected, of which 216 were suitable to study the results obtained from using Vitallium tubes in biliary surgery.

1. In 106 cases the tube was used to reconstruct the bile duct and preserve its continuity.
  - (a.) 85 cases (80.1 per cent) had good results.
  - (b.) 12 cases failed because of plugging of the tube, so the prevention of this is discussed.
  - (c.) 7 cases had the tube used to bridge a gap between the ends of the divided duct. All were failures.
2. In 79 cases a Vitallium tube was used in hepaticoduodenostomy.
  - (a.) 46 cases (58.2 per cent) had good results.
  - (b.) 30 cases (38 per cent) are known to have passed the tube.
3. In 18 cases an hepaticojejunostomy was done using a Vitallium tube. This group is too small for statistical significance, but the results are suggestive.
  - (a.) 15 cases (83.3 per cent) had a good result.
  - (b.) 7 cases (38.8 per cent) have passed the tube.
  - (c.) The Roux-Y appears better than the loop with entero-anastomosis, since all the failures were in the latter.
4. Vitallium tubes were also used in hepaticogastrostomy, in chronic pancreatitis, in inoperable carcinoma, and in pancreatic fistulae.
5. The Vitallium tube has allowed reconstruction of otherwise irreparably damaged bile ducts. This restores the normal anatomic channel. When the lower end of the common duct cannot be found or for any other reason this repair is not feasible, a Roux-Y anastomosis with hepaticojejunostomy appears to be the best substitute.

### BIBLIOGRAPHY

- <sup>1</sup> Allen, Arthur W.: A Method of Reestablishing Continuity between the Bile Ducts and the Gastro-intestinal Tract. *ANNALS OF SURGERY*, 121, 412, 1945.
- <sup>2</sup> Carlucci, G. A.: Reconstruction of the Common Duct with a Vitallium Tube. *Amer. Jour. Surg.*, 60, 209, 1943.
- <sup>3</sup> Cattell, R. B.: Benign Strictures of the Bile Ducts. *Surg. Clin. of North Amer.*, 23, 701, 1943.
- <sup>4</sup> Clute, H. M.: Bile Duct Reconstruction with Vitallium Tubes. *New Eng. Jour. Med.*, 226, 484, 1942.
- <sup>5</sup> Cole, W. H., Ireneus, C., Jr., and Reynolds, John T.: The Use of Vitallium Tubes in Strictures and Absence of the Common Bile Duct. *ANNALS OF SURGERY*, 122, 490, 1945.
- <sup>6</sup> Cole, W. H., and Elman, R.: *Textbook of General Surgery*. D. Appleton-Century Co., New York, 1942. Page 629.

- <sup>7</sup> Eisendorf, L. H.: Plastic Reconstruction of the Common Bile Duct: With Special Reference to the Use of Vitallium Tubes. *Med. Bull. Vet. Adm.*, **19**, 265, 1943.
- <sup>8</sup> Eliot, Ellsworth, Jr.: Benign Cicatricial Strictures of the Bile Ducts. *ANNALS OF SURGERY*, **104**, 668, 1936.
- <sup>9</sup> Hayes, J. M.: Common Duct Repair by Means of a Vitallium Tube. *Minnesota Med.*, **26**, 1064, 1943.
- <sup>10</sup> Lahey, F. H.: Strictures of the Common and Hepatic Ducts. *ANNALS OF SURGERY*, **105**, 765, 1937.
- <sup>11</sup> Lahey, F. H.: Finding the Lower End of the Cut Common Duct in Strictures of the Common Duct. *Surg. Clin. N. Amer.*, **23**, 714, 1943.
- <sup>12</sup> Lord, J. W., Jr., and Chenoweth, A. I.: Free Graft Over a Vitallium Tube for Bridging a Gap in the Common Bile Duct of the Dog. *Arch. Surg.*, **46**, 245, 1943.
- <sup>13</sup> Mall, F. P.: Reversal of the Intestine, *Johns Hopkins Hosp. Rep.*, **1**, 93, 1896.
- <sup>14</sup> Mann, F. C., and Bollman, J. K.: A Method for Making a Satisfactory Fistula at any Level of the Gastro-intestinal Tract. *ANNALS OF SURGERY*, **93**, 794, 1931.
- <sup>15</sup> Mayo, W. J.: Some Remarks on Cases Involving Operative Loss of Continuity of the Common Bile Duct. *ANNALS OF SURGERY*, **42**, 90, 1905.
- <sup>16</sup> Migliaccio, A. V.: Reconstruction of the Common Duct with Vitallium Tubes. *Amer. Jour. Surg.*, **70**, 261, 1945.
- <sup>17</sup> Pearse, Herman E.: Benign Stricture of the Bile Ducts Treated with a Vitallium Tube. *Surgery*, **10**, 37, 1941.
- <sup>18</sup> Pearse, Herman E.: Vitallium Tubes in Biliary Surgery. *ANNALS OF SURGERY*, **115**, 1031, 1942.
- <sup>19</sup> Pearse, Herman E.: The Management of Injuries of the Common Bile Duct. *New York State J. Med.*, **44**, 403, 1944.
- <sup>20</sup> Pearse, Herman E.: Common Bile Duct Surgery: The Use of Vitallium Tubes. *Conn. State Med. Jour.*, **9**, 507, 1944.
- <sup>21</sup> Walton, Sir James: Reconstruction of the Common Bile Duct. *Surg., Gynec. and Obst.*, **79**, 57, 1944.
- <sup>22</sup> Whipple, A. O.: Surgical Treatment of Carcinoma of the Ampullary Region and Head of the Pancreas. *Am. Jour. Surg.*, **40**, 260, 1938.

DISCUSSION.—DR. I. S. RADVIN, Philadelphia, Pa.: I think Doctor Pearse is to be congratulated for the excellent compilation and presentation he has made. The field is a very difficult one; as Doctor Lahey said some time ago, we would not have so many of these cases if the surgery of this area were done by surgeons competent to do it. There is no method, vitallium tubes, T-tubes, or catheters, or any other, which is suitable for all defects of the common duct and the hepatic duct. Doctor Pearse has pointed out two important features in this type of work. First, it is important to find both ends of the duct. All too frequently the lower end of the duct is not found and attempts are made to bridge the defect, when a more thorough search would have made permanent restoration more likely. The second matter is equally important; one must have mucosa-to-mucosa approximation. If this can be obtained a successful end-result is more likely. It may be better to do this anastomosis over a T-tube; it may be well to do it over a vitallium tube, or over an ordinary catheter, but the important thing is that we get mucosal junction. When we have used a T-tube, we have at times left it in for eight to thirteen months.

We have carried out in eight patients a method reported before this Association many years ago by John Speese, known as the Speese-Ginsberg procedure, and have had several very satisfactory results in the presence of massive defects.

DR. FRANK H. LAHEY, Boston, Mass.: It seems quite natural for me to be discussing strictures of the common duct on this platform because just four months ago on this very platform I discussed strictures of the common and hepatic ducts before the Southern Surgical Society.

It is impossible to report comparably on strictures of the bile ducts because in every group reported there are so many variables. If we were to talk about strictures of the common duct they would in our experience—and we have now operated upon 154 strictures of the common duct—be in the minority. Most of the strictures of the bile ducts that we have to deal with are the result of surgical accidents involving cystic or hepatic artery hemorrhage or difficulties with the junction of the cystic, common and hepatic ducts, and so the strictures in most of these cases involve the hepatic duct alone or the upper common and lower hepatic ducts. Many of the patients with strictures with which we have dealt have been operated upon several times, with the result that there is literally no hepatic duct left, and the only hepatic ducts which can be obtained are those which can be dissected out of the hilum of the liver by means of a fulgurating current. In not a few of these cases all of the hepatic duct has been destroyed and there remain only the left and right branches to which Y-tubes must be placed. This is why it is so difficult to report comparable end-results in these cases.

We have implanted 41 vitallium tubes. I have little faith in them. I think we have been under a misapprehension regarding them. We are, I believe, inclined to think of vitallium tubes as satisfactory structures because they are so well-tolerated by the tissues. The important thing in my opinion is not how well they are tolerated by the tissues but whether or not they plug any less often than do other types of tubes. I do not think they do. We have had a number of the vitallium tubes become completely occluded with biliary detritus, have had to take them out, replant other tubes and have them again plug. We had one case in which I implanted a rubber tube over a defect at least two and one-half inches long. This patient recently died at the end of eight years, never having been jaundiced at any time during the eight years, having lived quite comfortably, and yet at autopsy the rubber tube, which I have, was completely plugged and probably had been plugged for a great many years. All his bile had undoubtedly passed around the tube.

There is a material which I have employed which has all the advantages of a rubber tube and many advantages over vitallium tubes. It is a material called "bouncing clay," which we have obtained from the experimental laboratory of the General Electric Company. It is flexible, it will stretch, it will bounce like rubber and it can be cast in any shape. I am sure it has no advantages as to whether or not it will plug over either plain rubber or vitallium tubes. It does, however, have the great advantage in that it can be cast in any shape, that its flexibility permits its introduction into the devious channels which one often meets in strictures of the bile ducts, and that it is easily handled. My own feeling about vitallium tubes is that unless they possess greater likelihood of not plugging than do flexible tubes, their rigidity makes them not only difficult to introduce but at times dangerous because of the possibility of hemorrhage from pressure erosion.

We have learned that in most strictures of the duct the lowest portion of the common duct within the pancreas is intact. We have learned by splitting the lower end of the pancreas to find the common duct here and to demonstrate it well down to the point where it enters the duodenum. We have also learned that it is possible to so mobilize the duodenum that with this demonstrated portion of the duct, end-to-end anastomoses over tubes can frequently be accomplished.

I have just sent home a patient with a perfect intraductal anastomosis in whom, because of dilated hepatic and dilated common ducts with a stricture between the two, an accurate mucosa-to-mucosa anastomosis could be done within the duct.

Concerning the introduction of T-tubes, in articles on this subject some time ago, I proposed that the T-tube be introduced through a separate incision above the stricture and the suture line of the mucosa-to-mucosa anastomosis, in order that when it was withdrawn there would not be interference with the suture line. I feel sure that tubes can permanently be taken out when good mucosa-to-mucosa anastomoses



can be accomplished but when a defect occurs between mucosa and mucosa and scar tissue exists over any considerable area, contraction will eventually occur unless a permanent indwelling tube is left in position.

Strictures of the common and hepatic ducts are surgical catastrophes. The ultimate result in most cases, particularly in those in which repeated operations have been done, will not be satisfactory. We would not have these strictures if we had wide incisions, good exposure, good relaxation, and if it could be realized that while most gallbladder surgery is relatively simple, occasional cases occur which will tax the skill and resources of the most experienced surgeon.

I wrote an editorial on strictures of the common duct which I thought would cause considerable criticism. I think it should be repeated. It is to the effect that if a man injures the common and hepatic ducts during a cholecystectomy, he should seriously consider whether or not he has had enough experience to attempt to repair it. Agreement should be almost universal with the point of view that if a man has injured a common or hepatic duct and then has unsuccessfully attempted to repair it, he should not attempt it again, and this could go on almost indefinitely because we have operated upon these cases in which four or five attempts have been made to repair an injured duct. It should be remembered that the surgeon who has the first chance to repair the ducts after injury has the greatest opportunity of getting the best results, that with each repair there is loss of substance in the duct, a greater amount of scarring and less chance of a good result. It is for this reason that I have pleaded that these patients be sent to men who have been interested in and have had experience with the repair of strictures of the common duct.

One could rightly look with suspicion on this statement were it not true that in Boston, in New York, and in almost every part of the country there are men who have published articles on this subject and who have been interested in it, and for this reason I make this statement without fear of being suspected of any selfish interest.

DR. WALTMAN WALTERS, Rochester, Minn.: I think Doctor Pearse is to be congratulated for assembling the data contributed by members of our Association. One or two points should be stressed. The postoperative result is determined not alone by the accuracy of the anastomosis of the cut end of the common or hepatic duct to the opening made in the intestine, but also by the degree of infection in the wall of the duct as well as in the liver. It is quite possible to perform an accurate anastomosis between the end of the duct and the duodenum or a loop of jejunum and still have intrahepatic infection or secondary obstruction at the anastomosis.

Then the question arises of how to maintain a foreign body, such as a tube, in the duct at the site of the anastomosis. Perhaps you may remember McArthur's description of a method for anchoring a catheter in the common duct by passing a long silk suture through it. He brought this suture out of the incision and anchored it to the abdominal wall. I have used this method in many cases, and it is possible by this means to maintain a catheter at the site of the anastomosis of the hepatic duct to the duodenum for many months, even though there is intermittent peristalsis which tends to cause it to become displaced.

About the vitallium tube, I agree with Doctor Pearse, Doctor Lahey and Doctor Ravdin, and have to add only that it is a rigid tube. Its lumen may become obstructed by bile pigment and debris, whereas a rubber or plastic tube is probably elastic. Any tube at the anastomosis serves two purposes; one is to transmit bile; and the second is to serve as a splint during healing and to prevent contractures. Sir Harold Stiles and McIndoe have expressed the opinion that it is necessary to maintain a scaffolding for about three months to prevent contracture at the site of a plastic procedure for the maintenance of a lumen, be it at the ureteropelvic juncture, in the urethra or the vagina. I believe that such a principle may apply in certain, but not

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all, cases in which anastomosis is made between the common duct and the intestine. Some of the best results I have had in the performance of plastic operations for relief of obstructions of the biliary and genito-urinary tracts have been obtained when I did not use tubes or catheters of any type.

I did not use a vitallium tube before 1942, but then I thought I would try one in one case, and it worked satisfactorily. I passed the silk suture through a hole in the flange and carried it through the incision, where it was maintained in place with a button attached to the abdominal wall by means of adhesive tape.

In Doctor Pearse's first case a vitallium tube was removed two years after its insertion in the common duct and, when it was removed, the anastomosis was in excellent condition and without evidence of contracture. This observation is important in evaluating results. McArthur, employing the catheter method, reported good results in, I think, six or nine cases in which end-to-end anastomosis of the duct was made after excision of the stricture.

The results reported by members of the Association in treatment of this serious lesion are a great credit to the medical profession. The risk of the operation is high; the patients are in poor condition and damage to the liver is extensive. It seems to me it is important to emphasize the good results obtained in more than 50 per cent of the cases whenever the problem of recurrent stasis at the anastomosis is discussed.

In the treatment of stricture of the common duct the type of case in which a stricture is localized to a small portion of the common duct does not present the most difficult problem; but the case in which there is no extrahepatic duct does. In the latter type of case the greatest ingenuity is required to relieve obstruction and either to maintain a channel to the exterior or to produce an internal fistula. An aspirating needle inserted into the liver at the hilus usually will assist the surgeon in finding an intrahepatic duct. A catheter placed in this will relieve biliary obstruction and, in an occasional case, will produce pressure necrosis of the anterior wall of the duodenum, with the establishment of an internal fistula between the intrahepatic tract and the duodenum. I have had two cases in which such a passage has been maintained by keeping a urethral catheter in the sinus. I think we surgeons should keep on working to see what additional improvements can be developed in the management of these cases of stricture of the common and hepatic ducts.

DR. HERMAN E. PEARSE, Rochester, N. Y. (closing): I wish to thank those who discussed the paper. It is a well-known fact that when many different methods are devised for the same purpose, none are completely satisfactory. I hold no brief for vitallium, but so far as I can determine it is best tolerated of any foreign substance. Its disadvantage is that it is hard and unyielding and cannot be shaped or adjusted to meet the needs of every situation. Tantalum is more malleable but cannot be welded, so no anchoring flange can be attached to the tube. Rubber has a thicker wall and hence a smaller lumen. It was my dissatisfaction with the irritation and fibrosis caused by rubber that led me to use vitallium in the first place. Most plastics are phenolized resins, and may be irritating to tissues. Unfortunately, the common duct of animals repairs with such ease that it is not suitable to test different methods, so I fear we must continue to assess our results on human beings. I doubt if in the end any one method will always prove to be the best for, as Doctor Lahey says, circumstances in individual cases vary so markedly.

## TETANUS—A PREVENTABLE DISEASE\*

INCLUDING AN EXPERIENCE WITH CIVILIAN CASUALTIES IN THE  
BATTLE FOR MANILA (1945)

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BECAUSE of its dramatic manifestations, tetanus, one of the horrors of war, has been well recorded for centuries. In the Civil War<sup>1</sup> (1861-65), among 246,172 wounded there was an incidence of 2.07 per thousand. The disease has had a high mortality rate that has not been notably reduced. The progress in combatting tetanus since the causative organism was demonstrated between 1884 and 1890 has rested in its prevention and not its treatment. After the introduction of antitoxin during World War I (1914-18), the British<sup>2</sup> reported an incidence of 0.015 per thousand in 2,032,142 wounded, and the American troops<sup>3</sup> during the same war reported 0.016 per thousand among 224,089. Antitoxin provided a passive immunity when used prophylactically. An active immunity to tetanus was demonstrated to be produced by tetanus toxoid in 1921, shortly after World War I by the French Army.<sup>4</sup> In 1930, a tetanus toxoid was produced in the United States<sup>5</sup> capable of inducing a high antigenic titre which has since been used to protect all American soldiers against tetanus. In this war the use of tetanus toxoid has been, beyond all doubt, one of the most successful projects in preventive medicine. The absence of the disease is spectacular only by contrast. That there had been no clinical tetanus in American troops throughout the SWPA in the war attracted little attention until approximately 500 cases of tetanus developed among the civilian battle casualties in the battle for the capital city of the Philippines.

The fighting in and about Manila was intense and bitter throughout the month of February but had largely subsided by the latter part of March. The American soldiers who were engaged in this struggle had in common with the civilian population the general surroundings with the same bacterial flora and sustained similar wounds, and yet they escaped without a single instance of tetanus.

As Surgical Consultant of the Sixth Army, I had an opportunity to observe many of the civilian wounded in Manila. The medical importance of the high incidence and severity of tetanus then appearing was evident early and the collection of information and data about such patients was begun. The civilian hospitals operating under combat and siege conditions which prevented the preparation and accumulation of detailed records were

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aided by Army personnel, and in one instance the San Lazaro Hospital was operated directly by representatives of the Surgeon of the Sixth Army for a few weeks after American troops entered Manila. The account of the observations concerning the care of civilian battle casualties who developed tetanus represents information collected from all possible sources.

In order that the unusual background that provided such optimum conditions for the development of tetanus may be kept in mind, it is necessary to review some of the circumstances then existing. A city that is held and defended by one military force and attacked by another from the air and ground as well as by a not far off naval force soon becomes a place where the care of the wounded and sick is difficult indeed. Manila was such a place in February and March of 1945. The inhabitants could not flee the city; they were subjected to the action of Japanese military force as well as to the fire from the American elements besieging the city. The civilian population for long had been on a limited diet, and this was markedly curtailed with the onset of active fighting. The wounded accumulated from air bombing, artillery fire and small arms, hand grenades and bayonets and swords of the Japanese. The casualties were taken by relatives, friends, or bystanders to the hospitals. These institutions were also casualties — some had sustained direct hits; personnel had been depleted by enemy action in some instances, by urgent demands to administer to those outside the hospitals; some in attempting to protect their families had been cut off from returning, others had been commandeered by the Japanese. The result was that only a token number of the hospital personnel were in these hospitals, and under the prevailing confusion organization did not exist. The water supply was early cut off, the sewage systems became blocked, and the food supply was further limited, as it had been for some time before, and very quickly became almost negligible. The civilian hospitals were overfilled with the wounded, the dying, and the dead.

In the San Lazaro Hospital a few days after the beginning of the battle for Manila there were approximately 1,300 civilian patients, and over 1,100 of these had been wounded. One hundred and fifty-six cases of tetanus developed from this group. The picture of this hospital was a most unhappy one — it was overcrowded, all beds and all floor space were filled with the wounded, many dying, many dead. By and large, the dead had the most severe wounds of the head, thorax, and abdomen. However, among the living there were wounds of every part, approximately 70 per cent involving one or more of the extremities. An occasional wound had been closed but the majority had had no surgical care. Some wounds were covered with dressings of sorts consisting of parts of clothing. Bandages were few and flies swarmed over the partially exposed wounds. Fractures of the extremities were splinted for the most part only by the pain that prevented patients from moving. The patients, children and adults, exhibited all phases of injury, exsanguination, shock, infection, and malnutrition.

The location of wounds in the 156 patients who developed tetanus was as follows:

Head and face.....	20
Neck.....	1
Thorax.....	12
Abdomen and back.....	17
Buttocks.....	21
Pelvis.....	4
Upper extremities.....	34
Lower extremities.....	76
Burns and miscellaneous.....	21

There were many instances of multiple wounds. The number of patients with wounds of the head and neck who developed tetanus was small in comparison to those with wounds in other regions of the body. Compound comminuted fractures of the long bones associated with massive soft-tissue damage and extensive infection, on the other hand, seemed to be the type of wound most frequently associated with tetanus. Dependable and accurate data were seldom available as to the exact time of wounding and the onset of the symptoms of tetanus. It can be said with certainty that there were instances of tetanus being evident as early as three days and as late as 20 days from the date of injury. It may be estimated that 60 per cent of the patients who developed unmistakable evidence of tetanus did so within seven days.

The onset of symptoms was difficult to evaluate because of the general poor condition of these patients as described above. The vital processes were so depressed in the group and the clinical pictures so complicated by coexisting abnormal states and infections that they masked the classical early manifestations of the disease, such as the complaint of headache, stiffness of the neck muscles, and difficulty in chewing. Locked jaws were all too evident when fully developed, as were tetanic seizures and opisthotonos, and yet often these were the first manifestations of the disease to be observed. It should be stressed that the complaint of headache, stiffness of muscles, and pain in the region of the wounds could be elicited from the majority of the wounded.

Local tetanus was observed in the region of wounds and also in muscle groups proximal to the wound as well as the muscles of the entire extremity. Severe local tetanus associated with mild general tetanus was not uncommon, and muscle spasm both tonic and clonic was marked in the extremity where the wound was located. Usually the wound was located in the distal portion, as on the forearm or hand of the upper extremity and leg or foot of the lower extremity. Local tetanus involving an extremity independent of the wound was not seen. However, one patient developed local tetanus in the stump of a mid thigh amputation following removal of a gangrenous leg, the result of a compound fracture of the distal portion of the femur. Tetanus was not observed before the operation and local tetanus was present on the following day. It persisted for almost two weeks and subsided. During this period there was a slight trismus and almost no stiffness of the neck muscles.



The most frequently observed clinical picture was as follows: A patient with a wound of considerable extent in an extremity from 5-7 days after injury would be unable to open his mouth. There would be marked trismus and stiffness of the neck muscles. Associated with these two findings there would exist, or soon follow, mild spasms which fixed the head, body, and extremities in a straight line — orthotonos. Within a matter of hours as the seizures became more pronounced and more frequent, opisthotonos developed with greater involvement of the back muscles, so that during a spasm the back became arched and the body was truly supported by the head and heels. Concomitantly, there would appear the classical risus sardonicus with elevation of the eyebrows and retraction of the corners of the mouth, producing a grimace that exposed the locked jaws. Orthotonos was observed to be followed not only by opisthotonos but emprosthotonos. Spasm and rigidity of the abdominal muscles was an early and common finding that preceded generalized seizures and persisted during and between them. As spasms became more intense over a period of hours or days they rendered breathing difficult. With the muscles of the neck and diaphragm and the intercostals in spasm, the air exchange was so reduced that the lips and nail-beds became very cyanotic. During the severe spasms there was profuse perspiration, and pain was excruciating and unbearable. As the disease progressed and the spasms increased in severity and frequency, the patient became physically exhausted but remained mentally clear and terrified. An occasional patient died during a spasm, but the majority following complete exhaustion became listless, and the diminishing convulsive seizures were followed by death.

Dysphagia was common and present in about 75 per cent of all patients with tetanus, whereas trismus was more constant. A few (four) patients with a rapidly fulminating type of the disease did not exhibit trismus. The forearms and hands in the majority of tetanus patients were, in general, spared to a remarkable degree, so much so that even those with the most severe spasm could grasp the sides of the bed or cot during seizures.

The deep reflexes were early exaggerated, and the Babinski reflex was positive in approximately 20 per cent of new cases. Ptosis of the eyelids was observed in seven instances in the 156 patients. Facial paralysis was seen only once and no history could be obtained as to whether or not this was present before the onset of the disease. True cephalic tetanus as described in the literature was not observed. Extensor responses of the foot and leg on stimulation or during a convulsive seizure were common.

Those patients with generalized tetanus exhibited various degrees of urinary retention and without exception had difficulty in urinating. During a spasm urine would be expelled in small amounts. Although a spastic vesical sphincter has been the cause commonly ascribed to this, no difficulty was encountered in catheterizing men or women. Spasm of the rectal sphincter was readily demonstrated early in generalized tetanus. Fecal impactions were rarely seen because the food intake of most of the patients had for some time been negligible.

The great variation of extent and severity of the wounds in such a group of civilian battle casualties with little or no previous primary surgical treatment offered some opportunity to evaluate late operative therapy. Those patients with well-established tetanus who could withstand operation, although improved by such therapy so far as sepsis and general condition were concerned, seemed to follow the common pattern of the disease and with or without specific therapy died. The incision and drainage of grossly infected wounds, the removal of foreign bodies and the accompanying manipulation, on the other hand, did not appear to increase the progress or severity of the disease. Furthermore, guillotine amputation for extensive injuries of the extremities sometimes associated with gangrene and *Cl. welchii* infection did not appear to alter the course. However, it was significant that in the group of almost 40 patients in the San Lazaro Hospital upon whom amputations were performed and who had no evidence of tetanus at the time of operation and no other wounds, only three developed tetanus; two of these died and one ran a course of two weeks and eventually recovered. As previously stated, extensive wounds of the extremities involving deep structures accounted for the greater number of patients with tetanus, although there were also many examples of those who had superficial wounds. Burns in particular, with or without additional injuries, led to tetanus, although somewhat later. In a group of 37 patients with severe burns, ten developed tetanus ten days, or longer, after injury. The course of the disease in these patients was apparently just as fulminating as in those who developed the disease with a shorter incubation period, and all ten died.

Penicillin was used in six patients with tetanus. Daily amounts of 200,000 units were given to five of these in 25,000-unit doses intramuscularly every three hours. There was no apparent effect upon the tetanus infection. The period of treatment was as follows: two patients received penicillin for six days; one, for five days; one, for two days, and another for 36 hours. All ended in death. One child received a total of 1,200,000 units over a period of 48 hours, the initial dose being 25,000 units given intravenously and 50,000 units intramuscularly—this was repeated every three hours. Again the terminal course was unaltered. Penicillin was used locally in two patients who developed tetanus following burns. The wounds were grossly infected, and penicillin was applied in strengths of 500 units per cc. without evident improvement.

In the last three weeks of February at the San Lazaro Hospital, 140 patients in the group of 156 with tetanus died, a mortality rate of almost 90 per cent. That death was due to tetanus alone cannot be said because of coexisting conditions and other infections. There was little tetanus antitoxin for specific treatment. The facilities for general supportive treatment were also limited and sometimes even the most simple patient care was lacking. Many patients died within a few hours after the appearance of the symptoms of tetanus but many more lived for 3–10 days.

The single most important item available was morphine. This drug in

# TETANUS

.008-gram doses reduced the duration and the severity of the spasms. It gave the patient rest and enabled those with dysphagia to swallow liquids that could not have otherwise been administered. Morphine given as indicated, sometimes as often as every two hours, did repress respirations but it was the most useful of the drugs available and I doubt if pulmonary complications were increased by its use. Atropine, .0005 gram, given with morphine definitely improved respiration in severe spasms with marked opisthotonos.

Paraldehyde and chloral hydrate by rectum were well tolerated and effectual to a limited degree. The various barbiturates available were of minimal value. Severe and devastating generalized seizures were sometimes controlled by using chloroform and/or ether as a general anesthesia for short periods in order to give the patient some respite. Rectally, ether in oil, likewise, reduced convulsive seizures and was perhaps the best drug for the purpose under the prevailing conditions. Very little avertin was available but in the few patients who were fortunate enough to receive it the relief was gratifying. The Filipino physicians were unanimous in advocating the use of a 25 per cent solution of magnesium sulfate, injecting it intramuscularly in 2 cc. doses, and employed it almost routinely. It depresses respiration to an alarming degree. Sedatives of all kinds were of some value in controlling seizures and spasms, and by conserving the patient's strength life was frequently prolonged.

During February, March, and April of 1945, almost 500 patients were reported to have had tetanus in various civilian hospitals in Manila. Table I was prepared from information available from the hospitals:

TABLE I

Hospital	Cases	Deaths	Recoveries
San Lazaro.....	200	190	10
PCAU No. 20.....	150 plus	137	Few
Emergency.....	76	40	36
PCAU No. 5.....	22	6	16
Chinese General.....	16	10	6
Philippine General.....	6	3	3
Bilibud Prison.....	3	3	0
	473 plus	389	71 plus

It was estimated that there were, during this period, approximately 12,000 civilians wounded, and an incidence of almost 40 per thousand developed tetanus. The mortality rate for the 473 reported cases was 82.1 per cent. These patients for the most part had little or no primary or early surgical care. As far as is known, none had had tetanus toxoid before being injured.

According to the Filipino doctors during the decade prior to the war, there were about 75-100 cases of tetanus in Manila each year. The mortality ranged from 25-35 per cent. Many of the patients were brought to the hospital in the late phase of the disease. The specific treatment during this period was usually 40,000 units of antitoxin per day. Several Filipino doctors of considerable experience expressed the opinion that patients treated

soon after the development of the early manifestations of tetanus with antitoxin had a favorable prognosis.

In 1942, the first year of the Japanese occupation, there was only a slight increase in the total number of tetanus patients. There was little change in the status of the civilian population and there were very few war casualties. Hospital facilities had remained about the same and there was an adequate supply of tetanus antitoxin; thus, the mortality remained at the same level. However, in 1943 the mortality rose to 45-50 per cent. This increase was attributed to the diminishing supply of American antitoxin and the use of serum produced by local manufacture. The local antitoxin was not satisfactory because it was the first attempt to produce tetanus antitoxin in any quantity on Luzon. In the latter part of 1943 the horses being used for this purpose were taken over by the Japanese. Thus, by 1944 tetanus antitoxin had become very difficult to obtain and few patients received it.

During the last quarter of 1944, with the beginning of American bombings of Manila and the resulting casualties, the number of patients with tetanus increased. The mortality rate for the year was estimated as being over 60 per cent, and since there was no tetanus antitoxin available for civilians during the last 5-6 months of 1944, this is probably a conservative figure. In January of 1945 there was a further increase in casualties and medical supplies of all kinds were rapidly becoming exhausted. Sedatives in particular were scarce or unobtainable. The estimated mortality rate was raised to 80-90 per cent.

The incidence of tetanus in Manila under peace-time conditions would indicate that it would be high in combat. The American soldier was fighting under conditions quite similar as to climate and soil. His physical condition was, of course, superior to that of the average citizen of Manila. Furthermore, when wounded he received early and adequate surgical care and, in addition, he had been immunized with tetanus toxoid. That this immunization was completely successful is borne out by the complete absence of tetanus among the U. S. Army Forces on Luzon.

The record of the U. S. Army so far as tetanus is concerned in World War II approaches perfection. From December 7, 1941, to September 2, 1945, a total of 11 cases of tetanus was reported to the Office of the Surgeon General. Over a five-year period, from 1939 to 1943, there was a total of 3,105 deaths recorded as due to tetanus in the United States (Table II).

TABLE II  
TETANUS

DEATHS IN THE UNITED STATES OVER A FIVE-YEAR PERIOD

1939.....	637
1940.....	560
1941.....	602
1942.....	698
1943.....	608
Total.....	3,105

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In the U. S. Army for a five-year period that includes the War, 1941 to 1945 inclusive, there were 14 cases and four deaths. In 1941 there were three cases of tetanus reported, all prior to December 7 (Table III).

TABLE III  
TETANUS

CASES IN THE U. S. ARMY OVER A FIVE-YEAR PERIOD	
1941.....	3
1942.....	3
1943.....	5
1944.....	3
1945.....	0
Total.....	14

Table IV summarizes the patients with tetanus who were reported between December 7, 1941, and September 2, 1945.

TABLE IV  
TETANUS

U. S. ARMY—WORLD WAR II		
	Total Cases	Deaths
No active immunization.....	6	2
Basic immunization (3 injections)		
No booster injection after injury.....	2	2
Basic immunization and booster injection after injury..	3	0
Total.....	11	4

The length of service prior to injury of the six unimmunized cases occurring after Pearl Harbor was as follows:

Injury prior to entry on active duty .....	4
Four months of service .....	1
One year of service .....	1

The individual with four months of service was admitted to the hospital four days after induction for surgical treatment of a foot deformity and a cellulitis attributed to wearing GI shoes. He was hospitalized, received no routine immunization, and was subjected to two operations—the first, after the cellulitis had subsided, to correct the foot deformity; the second, for osteomyelitis which followed the first operation. Two weeks after the second operation mild tetanus occurred, from which he recovered. The individual with one year of service was inducted in January, 1941, and injured in February, 1942. Neither the immunization register nor the identification tag were available, but it appeared upon questioning the patient that he had had one dose of tetanus toxoid in November, 1941.

In two cases no booster injection was given immediately following the injury, although the patient had received his basic immunization. One of these patients was injured in North Africa and was first treated in a French hospital and later transferred to an American Evacuation Hospital.



The other case received his injury while on a furlough and was treated by a civilian physician. He received no toxoid until after the onset of the symptoms of tetanus which developed within 48 hours after the injury, and whereas this might be considered by some as a prophylactic booster injection, it was given because of the clinical manifestations of tetanus.

The routine administration of toxoid for stimulating purposes was given to three patients in the series. One of these had had three such injections at yearly intervals; the other two had one. (See Bayne-Jones, *etc.*) In the other two basically immunized patients, less than one year had elapsed since completion of their original series at the time of injury.

There were eight patients who did not receive stimulating doses of toxoid after their injury, and of these, six had received no active immunization. Two patients received tetanus antitoxin prophylactically. In several cases the nature of the injury was not such as would be regarded as requiring protection against tetanus according to the criteria so carefully defined in the Army Medical Corps regulations.

Of the 11 cases of tetanus that developed in the U. S. Army during World War II, only one occurred in a soldier wounded by enemy action, and this patient recovered. Only three soldiers who were fully immunized as prescribed by Army regulations developed the disease. There were four deaths. Two of these occurred in unimmunized personnel. There were no deaths in personnel fully immunized.

Table V indicates the nature of all injuries in this group.

TABLE V  
TETANUS  
U. S. ARMY—WORLD WAR II  
*Nature of Injuries*

Gunshot wounds.....	5
Burns.....	1
2nd operation for osteomyelitis.....	1
Compound fractures.....	1
Miscellaneous injuries.....	3
Total.....	11

The method<sup>6</sup> of immunization against tetanus in the U. S. Army has been provided for as follows:

Three (3) subcutaneous injections of tetanus toxoid are administered at intervals of 3-4 weeks. This produces an active immunization that can be reinforced or stimulated by 1 cc. of tetanus toxoid at intervals of one year thereafter. The following alone are indications for subsequent stimulating injections of tetanus toxoid:

- (a) Individuals who incur wounds or severe burns on the battlefield;
- (b) Patients undergoing secondary operations or manipulations of old wounds;
- (c) Others who incur puncture wounds, lacerations, severe burns or other conditions that might be complicated by the introduction of *Clostridium tetani* into the tissues.

The administration of tetanus antitoxin has been limited to the following:

- (a) To patients presenting clinical evidence of tetanus:
- (b) To individuals who incur wounds or other conditions which necessitate protection against tetanus but who have not previously completed the initial immunization with tetanus toxoid. At least 1,500 units of tetanus antitoxin should be used for passive immunization and at the same time active immunization initiated or completed with tetanus toxoid. Allergic reactions must be kept in mind when tetanus antitoxin is administered because it contains horse serum.

The success of preventing tetanus with toxoid in World War II is ample justification for proposing that all children be immunized against tetanus just as they are against diphtheria. If all school children were so immunized, we might well expect to reduce the incidence of the disease to a negligible figure. With tetanus toxoid immunization the use of antitetanic serum would be unnecessary. A booster shot of tetanus toxoid may be administered at intervals of two years, according to Bigler and Werner,<sup>7</sup> and of course in the presence of wounds indicating it. Anaphylaxis associated with the administration of serum had inhibited the production of a passive immunization, and justifiably so. So far as I know, no instances of fatal reaction in adults or children due to tetanus toxoid have been reported. This is in contrast to the experience with antitetanic serum which has been associated with occasional death.

#### CONCLUSIONS

The protection of the American soldier against tetanus by active immunization with tetanus toxoid during World War II is one of the most successful projects yet demonstrated in the field of preventive medicine. The high incidence of the disease amongst the civilian casualties in the battle for Manila (1945) is evidence that danger exists for the unimmunized. Present-day mortality rates indicate that the disease is best controlled by prevention rather than any known therapy of a curative nature. Immunization of all school children with tetanus toxoid should result in a decrease in the number of deaths that occur each year from the disease.

#### REFERENCES

- <sup>1</sup> Kirk, N. T.: Tetanus. Nelson System Surgery, Vol. I, Thomas Nelson & Sons—New York, 1938.
- <sup>2</sup> Bruce, D.: Tetanus. War Medicine, Paris, 1918; Vol. II; No. 5, 724.
- <sup>3</sup> Sick and Wounded Reports of Surgeon General on File Historical Division, S. G. O., Washington, D. C.
- <sup>4</sup> Ramon, G. and Zoeller, C.: Nouveaux résultats concernant la vaccination de l'homme contre le tétanos, *compt. rend.; Soc. de Biol.*, **100**, 92, 1929.
- <sup>5</sup> Hall, W. W.: Active Immunization Against Tetanus with Tetanus Toxoid. *U. S. Nav. M. Bull.*, **35**, 33, 1937.
- <sup>6</sup> War Department Technical Bulletin 114, War Department, Washington, D. C., November 9, 1944.
- <sup>7</sup> Bigler, J. A., and Werner, M.: Active Immunization Against Tetanus and Diphtheria in Infants and Children. *J. A. M. A.*, **116**, 2355-2366, May 24, 1941.

DISCUSSION.—DR. EDWARD D. CHURCHILL, Boston, Mass.: We have taken for granted this remarkable record of the Army in the prevention of tetanus in World War II, but from the facts Doctor Glenn has put before us, it stands as one of the notable achievements of surgery in this century. It can in no way be underestimated. This is brought home very forcibly when we compare the state of affairs among the German wounded. When the Emory University Unit took over a prisoner of war hospital near Marseilles they found seven cases of tetanus, many of whom died. I asked some of the German consultants why the Wehrmacht had not used tetanus toxoid, and he replied that the medical corps did not always have the support of the high command. They did, I believe, immunize the personnel of the Luftwaffe and some other specialized troops. The Italians did use it.

Certainly Doctor Glenn has called our attention to one of the notable achievements in preventive surgery in this war.

DR. WARFIELD M. FIROR, Baltimore, Md.: There are some papers so clear, so concise, so complete, that discussion is superfluous. Doctor Glenn's paper falls in that category. It serves to emphasize three basic facts about tetanus: First, it is a wholly preventable disease; second, when once well-developed, no form of therapy avails to prevent death; and, finally, it shows that the basic mechanism that brings about death is still unknown.

DR. FRANK GLENN, New York City (closing): I should like to thank Doctor Churchill and Doctor Firor for their discussion and to add one statement—that in my clinical experience I have never seen such a terrifying disease as tetanus.

## SURGICAL TREATMENT OF ANGINA PECTORIS\*

EXPERIENCES WITH LIGATION OF THE GREAT CARDIAC VEIN AND  
PERICORONARY NEURECTOMY

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IT IS WELL KNOWN that in coronary disease sensory disturbances, vasomotor reactions, and mechanical interferences with the coronary blood flow are always intimately interwoven. It probably never occurs that a single group of these pathologic phenomena acts alone. It is, therefore, fundamentally important to elaborate surgical procedures which would simultaneously block all the nervous deleterious influences and improve the mechanical conditions of the coronary circulation. This basic principle was never lost sight of in the experimental studies that we have carried on since 1935.

To improve the mechanical conditions of the coronary circulation, the value of coronary venous ligation was reinvestigated. To block the action of reflexes, all the important pathways to and from the coronary arteries were resected at the root of the aorta and the origin of the coronary arteries. This last procedure which is obviously more than a sympathectomy, as vagal, sympathetic and sensory branches are resected, is referred to as pericoronary neurectomy.

In 20 dogs, used as a control series, the circumflex artery was ligated at its origin; namely, two to four millimeters from the origin of the left coronary artery. Twenty per cent of the animals survived. In a second group of ten dogs, prepared in advance by coronary venous ligation, the circumflex artery was ligated as in Group I, about one month after. Forty per cent of the dogs survived. It is interesting to note that all the animals which died, except one, succumbed rapidly after the arterial occlusion. In a third group of ten dogs, prepared in advance by pericoronary neurectomy alone, ligation of the circumflex artery was done as in the previous groups at various intervals after operation. Sixty per cent of the animals lived. The interesting point to mention about this series is that not a single animal which died succumbed immediately after the arterial occlusion. In a fourth group of 15 dogs, prepared in advance by pericoronary neurectomy and coronary venous ligation, the circumflex artery was tied again as in the other groups. The survival rate rose to 86.7 per cent. These last results seem to indicate very clearly that coronary venous ligation combined with pericoronary neurectomy decrease substantially the mortality rate after a very high coronary occlusion.

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\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

Other experiments were carried out with Swenson to evaluate pericoronary neurectomy in abolishing anginal pains. The method originally described by Sutton and Lueth (1930) was used. The results obtained showed that pericoronary neurectomy abolished pain. In our control series of ten dogs, seven gave responses of a high degree which were graded (+++); two gave fairly good positive responses (++); one did not respond (-). In the latter, the negative result was undoubtedly due to the animal's poor condition at the time of the test. Ten dogs operated upon in advance by pericoronary neurectomy gave the following results: Six gave no responses at all (---); one was irresponsive in five tractions on the coronary artery and in one traction the result was questionable because the animal seemed restless (--); two gave doubtful reactions, for they were very active during the rest periods and it is difficult to conclude whether the activity they presented during the tests was due to pain or just to a normal behavior. One only had a positive reaction which was graded (+). It was concluded that pericoronary neurectomy, when technically well done, can abolish coronary pain.

Finally, other experiments were done to see if pericoronary neurectomy could prevent ventricular fibrillation appearing after sudden coronary occlusion. For this purpose, the adrenalin test was used. In a control series, two cubic centimeters of a solution of adrenalin 1:1000 was injected into the left auricular appendage of the intact dog's heart. A sharp elevation in the blood pressure immediately followed, accompanied by ventricular tachycardia and arrhythmia. No ventricular fibrillation occurred. Gradually, the blood pressure and cardiac rate returned to normal. In another series, either the ramus descendens or the circumflex branch of the left coronary artery was ligated at a level that was known by many previous experiments as not high enough to determine ventricular fibrillation within at least one hour after occlusion. One or two minutes after ligation, the same dose of adrenalin as used in the previous group was administered into the left auricular appendage. In all cases, ventricular fibrillation developed within one or two minutes. In a final series, prepared in advance by pericoronary neurectomy, the same procedure as in the latter group was carried out. It was immediately followed by a sharp elevation in the blood pressure, ventricular tachycardia and arrhythmia. In no instance did ventricular fibrillation develop. It seems, therefore, that pericoronary neurectomy helps substantially to prevent fibrillation following coronary occlusion.

The physiologic basis of coronary venous ligation and pericoronary neurectomy as well as the reasons for their association have been discussed at length in other papers. Needless to say, the experiments reported briefly today illustrate clearly that it is fundamental to act simultaneously against both mechanical and vasomotor disorders in coronary disease to achieve better results through operation. Finally, they suggest that coronary venous ligation combined with pericoronary neurectomy should be tried and carefully studied in correctly selected cases of coronary disease.



Sixteen cases have been operated upon during the past six years. They are divided in three groups: In the first, only coronary venous ligation was done. At that period, the experimental work on the coronary nerves was not advanced enough to allow denervation in patients. This group has, however, the advantage of showing the value and limitations of the procedure when used alone. The second group consists of cases of coronary venous ligation combined with pericoronary neurectomy. In the third group—only one case—pericoronary neurectomy alone was performed.

All these patients had a history of coronary thrombosis confirmed by electrocardiographic tracings. Some of them gave a history of two or three attacks of coronary thrombosis. All were practically disabled by "angina of effort" and did not respond to rest and medication. Three died either during or rapidly after operation. In the first group, the cause was pneumothorax tension; in the second, intoxication by quinidine; and in the third, rapid cardiac failure, both coronary arteries being totally occluded at the aortic orifice.

Two of these cases have succumbed since operation. One, a 65-year-old patient with angina and cardiac failure, was discharged from the hospital relieved of his pain. He died three months later from progressive cardiac failure. The other lived during 2.5 years after operation. Before coronary venous ligation, he was not able to walk a block without dyspnea. The slightest emotional upset provoked marked pain. Five months after operation, he walked five miles without resting and had no discomfort. He resumed his work as a janitor. Up to the time of his death, he was examined frequently, and the marked improvement in his condition noticed after ligation was maintained. He died suddenly. His heart was examined and histologic sections showed a high degree of vascularity of the cardiac muscle. Vessels of the posterior and anterior papillary muscles were markedly dilated and gave the appearance of being cavernous. Actual pools of blood were also found in the sections.

Eleven patients are still living; one, six years after the operation. At the age of 65 he is working; his only complaint is a slight dyspnea after exertion. He is now obese and hypertensive. Three patients were operated upon approximately five years ago; they all do the same type of work in which they were engaged before coronary disease incapacitated them, and they have no anginal pain. In the recent group of three patients in which coronary venous ligation was combined with pericoronary neurectomy, one patient is working steadily and has been for 1.5 years; he does not complain of angina. The second case is much improved but states that at the end of the day he often feels pain in his chest of less intensity than before the operation. The third case, operated upon last November, is remarkably well. Before November he was unable to work on account of angina. Subternal pains occurred with bowel movements, and after marital relations, or walking on the level. Since the operation, this pain has been absent. In January he walked in a snowstorm, face against the wind, and

reached his home without having pain or the slightest discomfort. On another occasion, he walked two miles without resting, and immediately afterwards ate a hearty meal. This was not accompanied or followed by angina. He admits that he never could have done this a year ago.

In one severe case, it was necessary to perform the operation in two stages. In the first stage, the ribs were partially resected; and in the second stage, denervation was done. Coronary venous ligation was omitted because we did not dare to prolong the operation. The blood pressure was at a low level. It is too early to evaluate the results in this patient. Yet it is encouraging to note that, since the operation, he has improved a great deal. Formerly he took about six nitroglycerin pills, but now he does not need this medication.

DISCUSSION.—DR. ELLIOTT C. CUTLER, Boston, Mass.: In this afternoon of brilliant papers, I hope this contribution by Doctor Fauteux will take its place as a valuable contribution. In this Association, the greater number of Fellows work in excellent hospitals, and have every facility for assisting and stimulating their pupils in investigative work. Doctor Fauteux has conceived and planned all his work himself. He came to us five years ago, and has continuously prosecuted experimental work out of his own experience and imagination. He has been helped by us largely through technical assistance, and what credit is forthcoming belongs to him alone.

To those interested in the application of surgery for relief of angina pectoris it is common knowledge that two major surgical plans have been proposed:

(a) The first plan is that originated by Francois Franck, a French physician in the last century, who proposed that the division of the sympathetic nerves in the neck might diminish the anginal pain. This procedure was largely practiced in Europe and completely elaborated upon by Rene Leriche. It has received further modification in this country at the hands of J. C. White, and others.

(b) The second method is that which seeks to bring a new blood supply to the heart devitalized by coronary disease. This school of thought is best represented by C. S. Beck in the United States and O'Shaughnessy in England.

Doctor Fauteux has, for the first time, tried to bring these two schools of thought into a common method, and the paper presented today has, I believe, made clear that both the neurologic elements, as well as the injured myocardium, must be considered in any thoughtful attack upon this problem. Moreover, he has brought the neurologic attack to the heart itself and, thus, avoided any injury to the accelerator or depressor apparatuses. His addition of vein ligation as a means of improving the local blood supply is a method which, though it has not produced benefits in other fields, has, by his experiences, seemed to produce benefits in relation to the myocardium.

Finally, he seems to have made secure his point that ischemia *per se* is not the cause of fibrillation, which is the vital element in this disorder. If this be so, it certainly strengthens his viewpoint that interference with the neurologic apparatus must also be utilized in attacking this condition.

DR. CLAUDE S. BECK, Cleveland, Ohio: I want to congratulate Doctor Fauteux on this work. I believe it is an important contribution and I should like to give him every encouragement to keep on with it. This work is difficult. It is difficult in the laboratory where the experiments are done, and it is difficult in the Clinic where laboratory ideas are applied to patients afflicted with coronary artery disease.

I cannot discuss reflexes in the heart. In our work we purposefully avoided consideration of reflexes. I believe the key to the coronary artery problem is in arterial blood supply and oxygen. The fundamental concept underlying our work can

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be demonstrated by a simple experiment. A dog's heart is exposed. An area of the left ventricle is selected for the development of a trigger. This area is about two centimeters in diameter. About five small arteries can be seen entering this area. These arteries are ligated. As they are ligated the area becomes cyanotic. If you ligate three or four of these vessels and close the incision, recovery takes place and the heart functions normally. If you continue with the ligation and ligate the remaining artery something suddenly happens. The coördinated beat is destroyed or is replaced by convulsive twitchings of myocardium. Arterial pressure falls to zero. The respiratory center dies and irreversible death follows. To this anoxemia area of heart muscle I applied the term "trigger." To the phenomenon that converted the coördinated contraction and relaxation of muscle fibers into incoördinated contractions I applied the term "discharge." In the presence of coronary artery disease trigger zones develop, discharge and kill. The relationship to blood supply is obvious. A small amount of arterial blood delivered to the trigger can be effective in preventing discharge. A new set of coronary arteries is not necessary.

Blood supply to the myocardium can be augmented in several ways. One, is by the production of extracoronary anastomoses. These are communications between the coronary arteries and the arteries of tissues grafted upon the heart. The second, is by development of intercoronary communications. This is brought about by production of inflammatory reaction on the surface of the heart. The third method is by coronary vein ligation. We studied this subject,\* and concluded that ligation of vein had some beneficial effect, that beneficial result probably was not great enough to make application to patients with coronary artery disease, and we suggested that measurements be made by other experimenters. Doctor Fauteux obtained beneficial results by ligation of coronary vein.

I should like to urge members of this Association, who have experimental laboratories, to study the coronary problem. Experiments, well controlled, will be important in advancing this work. Experiments, poorly controlled, will retard development. This experimental work requires accuracy and precision. The importance of the coronary problem is obvious. Again, I want to congratulate Doctor Fauteux.

DR. JAMES C. WHITE, Boston, Mass.: To me this paper is extremely interesting. Interesting because it suggests that there is a possibility that by interrupting vagus as well as sympathetic fibers you may get a better result, and further that by ligating the coronary vein you may get a better result still. In the sympathectomies I have been doing by the posterior approach through the second rib, every patient who has had removal of the three upper thoracic sympathetic ganglions has had relief from precordial pain and arm radiation, but all have known when they were doing too much in the way of exertion—a sensation, not pain, which told them to take nitroglycerin. I would like to know what warning sign there is after Doctor Fauteux's operation. I would also like to know if Leriche has not already shown that after sympathectomy alone the experimental animal is protected from cardiac fibrillation and the mortality rate from high coronary ligation is reduced.

I cannot give you the present exact figures on our patients at the Massachusetts General Hospital, nine of whom have had upper thoracic ganglionectomy and 75 chemical block of the cardiac nerves. Suffice it to say that everyone who has had evidence of effective denervation has been relieved of his intractable angina pectoris. It has amazed us how men, totally incapacitated, who had angina on any effort or even in bed, would come back, so that many could lead lives of moderate activity, and some have been alive and comfortable years afterward. We will check on this again. I hope Doctor Fauteux will go on with his work in Boston, and that we can compare notes on this group of cases.

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\* The American Heart Journal, 21, No. 6, pp. 767-779, June, 1941.

DR. MERCIER FAUTEUX, Boston, Mass. (closing): It is difficult to show in a few words whether the mechanism of ventricular fibrillation in coronary occlusion is due to ischemia or other factors. We are certain, in our minds, however, that it is not due to ischemia *per se*. Ischemia of the heart was produced by us in dogs in different ways. In these experiments, cardiac standstill was never caused by ventricular fibrillation. The heart gradually lost its strength and stopped in diastole. In the experiments, mentioned briefly by Doctor Beck, where three or four small ligated vessels produced fibrillation, his results, according to his interpretation, indicate obviously that localized cardiac ischemia is the cause of fibrillation. Any ligation of coronary arterial branches disturbs the coronary pressure. We have carried out experiments which show definitely that any localized and abrupt change in the coronary pressure can produce fibrillation, even without concomitant ischemia. Other experiments demonstrate that, after coronary denervation, even in the presence of cardiac ischemic conditions, the heart does not fibrillate. So, in our minds, we believe that we are beginning to see more clearly the mechanism of ventricular fibrillation after coronary occlusion, and we believe that, if ischemia is the cause, it is not the only one and probably not the most important one.

To answer Doctor White about the signs that replace anginal pain after pericoronary neurectomy, we found that in these patients a sensation of tightness or slight pressure, probably corresponding to their former pain, develops when they overtax the heart. It has been mentioned in regard to the value of sympathectomy in diminishing the incidence of ventricular fibrillation, that the work of Leriche showed that after sympathectomy the mortality rate was lower following coronary ligation. This has been confirmed by most of those interested in experimenting with coronary ligation. In pericoronary neurectomy, however, not only sympathetic branches are resected, but also vagal and sensory branches. The latter procedure seems to have a greater value in the prevention of ventricular fibrillation after coronary occlusion than does simple sympathectomy.

## MANAGEMENT AND REHABILITATION OF NAVAL BATTLE CASUALTY AMPUTEES\*†

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THIS REPORT is based on the study of 769 patients who had a total of 829 amputations. Fifty-eight of the patients suffered from partial loss of two limbs, while one patient lost three. It will be noted in Table I that 568 amputations involved the lower extremities and only 261, or approximately one-third, the upper extremities.

Amputations were performed in 757 cases because of trauma. Combat was the cause or circumstance of injury leading to amputation in 489 cases, or 64.6 per cent of the 757 cases (Table II), whereas, accidents while on duty led to amputation in 188 cases, or 24.8 per cent. In only 80 cases, or 10.6 per cent, did the accident occur during liberty or leave.

Five hundred and seventy of the original amputations were performed by the now classical guillotine technic, 45 by "open-flap" method, in which partial or adequate flaps were saved and 214 with primary closure. It was noted that when flaps were left, the wound healed much more rapidly and with no more complications than when no flap was left. In those wounds that were healed at the time of this survey, the average healing time of the usual guillotine stumps was 4.5 months, while those on which the open-flap method was employed were healed in an average of 3.5 months.

It has been our policy to secure healing of the wound following the primary amputation and then wait one month before final revision or re-amputation. An analysis of 77 operations performed upon unhealed stumps, here and elsewhere, revealed that serious postoperative complications developed after 27, or 35.1 per cent. This percentage should be compared with later figures on 379 operations on healed stumps in which postoperative complica-

\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

† This article has been released for publication by the Division of Publications of the Bureau of Medicine and Surgery of the United States Navy. The opinions and views set forth in this article are those of the writers and are not to be considered as reflecting the policies of the Navy Department.

‡ Dr. Walters has now returned to the Mayo Clinic as head of a Section on Surgery.



tions followed only 64, or 16.9 per cent. These figures show the rationale of waiting for complete healing. This policy, however, presented the greatest problem encountered on this amputee service, for healing of stumps was often slow and prolonged; thus, the period of hospitalization was extended and participation in the outlined program of rehabilitation was delayed.

TABLE I  
AMPUTATIONS

	Amputations
Upper extremity:	
Fingers.....	45
Partial hand.....	22
Forearm.....	79
Arm.....	115
Total.....	261 (31.5 per cent)
Lower extremity:	
Toes.....	24
Partial foot.....	44
Below knee.....	230
Thigh.....	270
Total.....	568 (68.5 per cent)
Grand total.....	829

Numerous methods were used to promote healing. These included whirlpool baths, applications of infra-red and ultraviolet light, various antiseptics and antibiotics, skin traction and skin grafts. Whirlpool baths seemed to stimulate healing in those cases in which peripheral circulation was adequate and the region to be epithelized was small or of moderate size. Split-skin grafts were of value even when they appeared to be failures because they apparently stimulated vascularization of the granulating tissue.

Cultures were taken of these wounds (Table III), but the rôle of bacteria

TABLE II  
CAUSES OF INJURIES: 757 CASES

	Cases	Per Cent
Combat.....	489	64.6
Accidents on duty.....	188	24.8
Accidents on leave or liberty.....	80	10.6

TABLE III  
TYPES OF BACTERIA FOUND IN WOUNDS LISTED IN ORDER OF FREQUENCY

1. *Staphylococcus aureus*
2. *Pseudomonas aeruginosa* (*Bacillus pyocyaneus*)
3. *Escherichia coli*
4. *Bacillus subtilis*
5. *Proteus vulgaris*
6. Nonhemolytic streptococci
7. Hemolytic streptococci
8. *Streptococcus faecalis* and rarely *Clostridium* and *Gaffkya tetragena* (*Micrococcus tetragenus*)

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in inhibiting healing could not be determined. The bacteria found were typical of those usually found in chronic wounds, and they probably represent a reflection of the type of nutrient available rather than a tissue infection.

Simple dry dressings of fine-mesh gauze were used as the fundamental or basic dressings. For approximately one-third of the stumps, these appeared to be the dressing of choice, although healing was seldom rapid. Various types of local treatment were used to promote healing. These included most of the acceptable ointments and solutions. The effect of topical medication on the rate of healing of open stumps has varied so widely that it is impossible to say that any one agent has been particularly effective (Table IV).

TABLE IV  
EFFECT OF CERTAIN LOCAL AGENTS ON HEALING OF OPEN STUMPS

Agent	Stumps Treated	Results				Per Cent Improved
		Made Worse	No Change	Slightly Improved	Improved	
Hypertonic solution of sodium chloride.....	7	0	4	1	2	28.6
Solution of chlorophyll.....	10	2	3	3	2	20.0
Azochloramide.....	52	0	32	11	9	17.3
Streptomycin.....	37	0	20	10	7	18.9
Penicillin.....	19	0	9	7	3	15.8
Zinc peroxide.....	71	2	28	24	17	23.9
Castellani's paint and elastoplast	19	4	2	2	11	57.9
Daily whirlpool bath.....	32	5	13	5	9	28.1
Total.....	247	13	111	63	60	24.3

Therefore, these agents were employed primarily in preparing the stump for skin grafting. The most useful agents for this purpose were 2 to 5 per cent solutions of sodium chloride, zinc peroxide and streptomycin. The hypertonic solutions of sodium chloride and zinc peroxide were found to be valuable in removing slough and purulent exudate, as well as in reducing edema. Streptomycin was used topically to eliminate the gram-negative bacilli, particularly *Pseudomonas aeruginosa* (*Bacillus pyocyaneus*). Although it effectively accomplished this purpose, it did little toward influencing healing or actually increasing the percentage of takes of the skin grafts. Daily whirlpool baths were useful in cleansing the lesions prior to grafting.

When the wound had not healed after several months and there was extensive fibrosis of the stump the application of Castellani's paint, followed by an elastoplast wrapping which encased the entire stump, promoted healing in 11 out of 19 cases. These dressings were left in place for five to ten days and were used in the same manner as Unna's paste boots for varicose ulcers.

It was apparent that the wounds in which adequate skin traction was employed from the time of operation healed much more rapidly than those in which this procedure was neglected or contraindicated. Anteroposterior application of moleskin tape, with or without a spreader, moleskin tape on four sides, with a spreader, and stockinette traction with which Unna's paste,

rubber cement or special adhesive compound is applied were used as indicated and alternated to suit conditions. In spite of the various procedures and materials used, in some cases it was impossible to maintain adequate traction on the skin because of perspiration, local irritation of the skin, associated injuries or lack of coöperation of the patient.

#### REVISION AND REAMPUTATION

After healing of the open stump had occurred, plastic repair or revision was usually a simple operative procedure. It consisted of excision of the terminal scar, preferably with a horizontal elliptical excision, and of undermining the proximal skin and subcutaneous tissue as indicated. The bone and its adherent fascia was not molested unless reamputation was contemplated. When closure was made under any degree of tension, skin traction was applied. If painful neuromas were present, these were removed at the time of revision by isolating the nerve, placing moderate traction downward on it and transecting it with a sharp razor blade at a higher level. Nerves were not routinely injected or ligated.

In these plastic revisions it is not possible to keep to the principles of good surgery, because closure was always accomplished under some degree of tension, over an ischemic region in which complete hemostasis was almost impossible to obtain.

The levels of amputation of choice are given in Figures 1 and 2.

Disarticulations through the wrist, intercarpal or carpometacarpal joints were done in five cases, and a prosthesis which utilized the pronation-supination function of the wrist has been constructed for use in these cases. By this means the cross-shoulder halter was eliminated and more direct control of the movement of the prosthesis was achieved. It was found that the styloid processes of both the radius and the ulna must be intact before use of this type of prosthesis was feasible. When the short stumps of the forearm were of inadequate length for a prosthesis, additional length could be gained by grafting skin and bones or by transferring the biceps tendon to the brachialis insertion. Lengthening of the humeral stump was done in a few selected cases in which it was indicated. The head of the humerus was retained for better cosmetic appearance and easier fitting of a prosthesis.

For the lower extremity, we have preferred the Syme amputation for amputations about the ankle, while in two cases the Boyd type of arthrodesis has been performed. After amputation about the knee, two patients have been fitted with a bent knee type of prosthesis, but the majority of our conversions were to a Gritti-Stokes type. The head of the femur was retained if possible, to give a wider base to rest on a tilting table type of prosthesis.

#### ASSOCIATED CONDITIONS

Associated injuries were common in these patients. Of the 757 patients who had amputations because of traumatic injury, 406 or 53.6 per cent had associated injuries. There were 149 cases of fracture, of which 90 were cases

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of compound fracture and 59 of simple fracture. Extensive loss of tissue, bone, muscle and skin was associated with the compound fractures sustained in combat. In 23 cases, or 25.5 per cent of the cases of compound fractures, osteomyelitis developed.

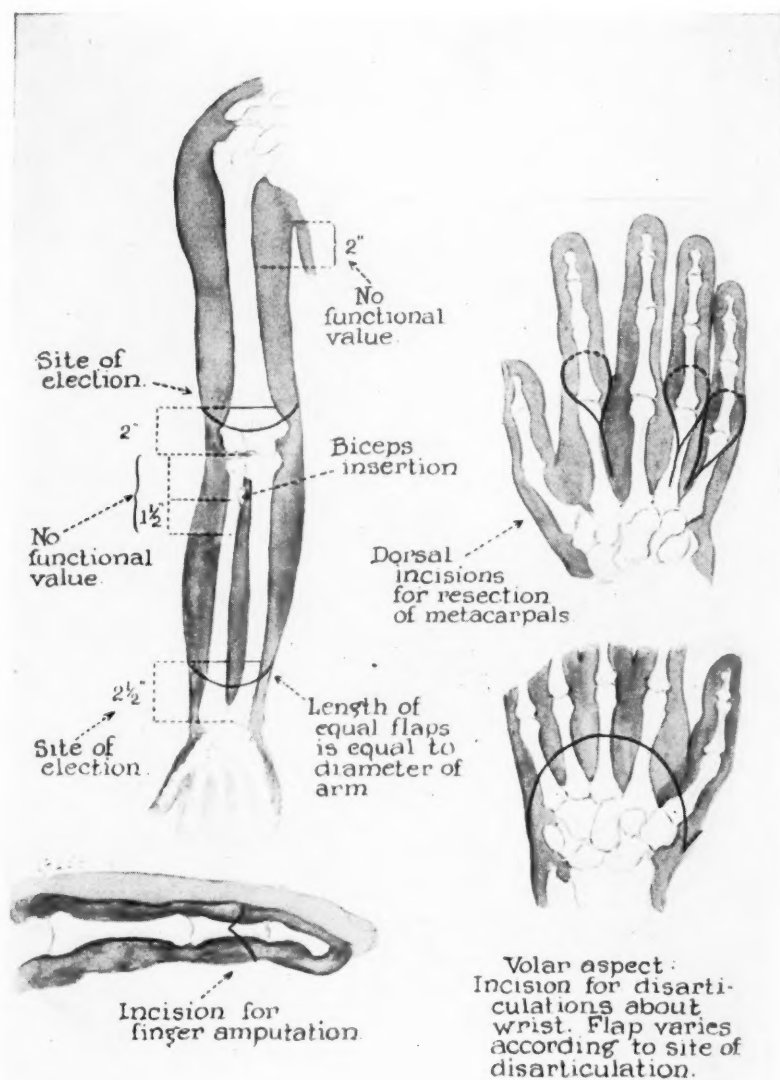


FIG. 1.—Amputation levels and skin incisions on upper extremity.

Contracture of the joint proximal to the site of amputation was found in 84 cases. This was due to scar tissue, muscle imbalance, painful stump and, finally, contracture of tissue about the joint. Physiotherapy and supervised muscle exercise, such as weight lifting, improved the condition in the ma-

jority of cases. Wedge casts, traction and manipulation under anesthesia improved the contracture in most of the remaining cases. Tenotomies were required in only a few cases.

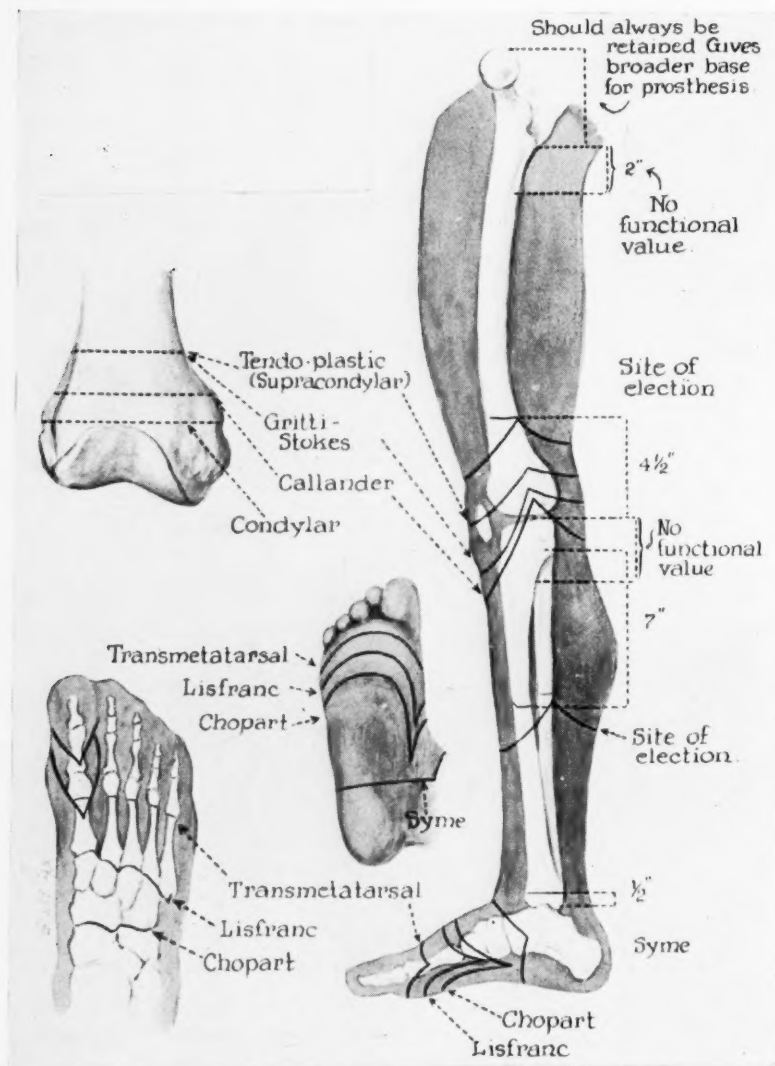


FIG. 2.—Amputation levels and skin incisions on lower extremity.

Extensive damage to the proximal joint due to penetrating wounds with infection and subsequent destruction of the articular surface occurred in 14 cases. Treatment consisted of immobilization of the joint in the position of maximal function, adequate doses of penicillin and sequestrectomy when indicated.

Twenty-five patients had associated nerve injuries. In the cases in which



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wrist and foot drop occurred braces were employed and physiotherapy was carried out before and after exploration by the neurosurgeon.

### PROSTHESES AND REHABILITATION

We have been fortunate in having an artificial limb shop in our department, under the supervision of Lt. Basil Peters, who had had 20 years of experience in the making of artificial limbs. The limb shop was staffed by Service personnel who had had no previous experience in making artificial limbs, but who had aptitudes in allied fields, such as leather-working, wood-working, *etc.* A laminated plastic was used as the basic material. This was formed by wrapping cotton duck canvas around the limb mold and impregnating it with a plastic resin glue. The plastic material may vary in thickness from three- to five-ply, or from  $\frac{3}{32}$  to  $\frac{1}{8}$  of an inch (0.24 to 0.32 cm.). A total of 513 prostheses were constructed in the 18-month period covered in this report.

Classes in driving automobiles were instituted in November, 1944, and have been of great value. The course consisted of several lectures on the elements of highway safety, instruction in a laboratory car on rollers, and practice with the Aetna reactometer to lessen the time for braking. Advanced instruction was given in the streets of Philadelphia and the final examination was given by the Pennsylvania State Police.

Follow-up data were available in 200 cases (Table V). Approximately

TABLE V  
FOLLOW-UP DATA ON REHABILITATION IN 200 CASES

	Per Cent
Back to old job.....	20
New job.....	38
School or college.....	20
No activity yet.....	22

78 per cent of these patients were either working or continuing education. A permanent lack of adjustment is not necessarily indicated for the group who reported no activity, as some of these patients had been discharged only recently. Some were taking a "well-earned rest," as they said; others are availing themselves of unemployment insurance.

### CONCLUSIONS

1. Open-flap method of amputation is recommended for amputations performed as emergency measures.
2. The early and constant use of skin traction cannot be too strongly stressed.
3. Various local agents are of value in eliminating certain types of bacteria from granulating wounds in preparation for skin grafting, but have not been found to hasten healing.
4. Revisions and reamputations through healed wounds are recommended whenever possible.

5. Disarticulations through the wrist, intercarpal or carpometacarpal joints are offered as satisfactory amputation levels.

6. With an adequate rehabilitation program, a large number of amputees are returned to a satisfactory and productive civilian life.

DISCUSSION.—LT. WILLIAM L. WHITE, Philadelphia, Pa.: My particular chore in this program has been concerned with healing of these open stumps before the final revision or reamputation. At six to ten weeks, or more, following guillotine amputation, when these patients were admitted to Philadelphia Naval Hospital, the stumps usually presented a uniform appearance, with the bone ends being covered by a pad of fibrous tissue of varying thickness, on the surface of which there was usually pale, dirty granulation tissue. These lesions are not unlike other indolent ulcers in which healing is retarded by inadequate blood supply. The most serious healing problems were encountered in below knee and partial foot amputations. We have endeavored to preserve all functional joints and bone length even at the expense of extended hospitalization, which is sometimes costly in view of the patient's mental adjustments.

The measures we have employed to secure healing may be divided into five classes as follows: First, the routine use of skin traction; second, local therapy designed to eliminate bacteria or improve the state of the wound; third, the use of the Thiersch grafts or pinch grafts; fourth, open revision of the wound with partial or secondary closure; fifth, the use of pedicle grafts, the value of which has not yet been determined, since none has been given an adequate test of time. Probably the best method in healing stumps has been the use of free split-thickness grafts.

MAJOR GENERAL NORMAN T. KIRK, Washington, D. C.: I want to congratulate the essayists. The paper presented is an excellent analysis of quite a group of amputees. Our experience in the Army more or less corresponds with the report made. Our job, of course, was quite a bit larger.

Five amputation Centers were initially set up by the Army. This number proved to be insufficient and was increased to seven. Initially, it was intended that only 750 patients be treated in any one Center; actually, there have been more than 3,000 amputees admitted to Percy Jones General Hospital since its opening.

I cannot agree with the statement that the flap-type guillotine amputation is superior to the circular type. Our experience in this war and the opinion expressed by our civilian consultants was to the effect that the circular type guillotine was the operation of choice in battle casualties where extremities had to be removed following trauma or to control infection. The circular type guillotine is not a "chop" operation. If it is properly performed there is ample soft tissue for closure without bone shortening. In the amputation by the open-flap method, traction is applied with difficulty; yet it is essential. Flaps frequently shrink and deform and do not present nearly so nice a stump after healing as does the circular type.

Skin traction, using adhesive plaster or skin glue with stockinette, is a part of the after-treatment of the open reduction and is as essential as a Levine or Miller Abbott tube for the treatment and control of ileum or intestinal obstruction. It is at times applied with difficulty and its maintenance is sometimes difficult, but not impossible if there is a will to carry it out.

Our experience has shown that a disarticulation at the wrist can be well fitted with a prosthesis and pronation and supination retained. Northrop has developed an excellent forearm prosthesis which permits pronation and supination of the appliance with amputation as high as the juncture of the upper and middle thirds of the forearm.

We feel that the skin grafting of the unhealed stump end prevents what we desire to accomplish by skin traction, and if the latter is properly applied the former will not be necessary. An unhealed area in the stump end is not *per se* a contraindication to

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plastic revision. If the wound looks clean and healthy and the stump end is free from edema, closure is just as safe from an infection standpoint as if the stump end has been previously skin-grafted.

Fortunately, with the use of sulfa drugs and penicillin, the infection rate following the plastic closure of stumps is much less than in World War I. I am unable to state at the moment the exact instance of infection and other complications such as hematoma or necrosis. Fascia closure in the repair of the circular type guillotine stump is not essential, as it is in the primary one-step closed operation. Skin grafts will not stand up when the prosthesis is worn. Pedicle grafts may be used, but before the prosthesis is applied innervation of the graft must have become effected or atrophic changes will occur.

CAPTAIN T. G. HAYS, Philadelphia, Pa.: I would like to say a word about rehabilitation in connection with amputees. The amputee gives an excellent opportunity to do rehabilitation work that will enable him to go out to a useful occupation. When he enters the hospital, he is given a physical examination, the stump is examined, roentgenograms are ordered, and then he is interviewed by the educational service officer. He is asked what education he has had, what he would like to do in the future, how much schooling he desires. Well-qualified instructors are available from the best institutions; courses can be obtained; any textbooks desired can be had, and the amputee can start training for his future in life while still under treatment, which I think is very important. Study keeps these patients occupied, and we know a person who is busy is not a trouble maker. Typing is taught, with typewriters adapted to the use of the individual. Physical training is started at that time and each is given a work-training project. They start training for the work they intend to carry on and are able to obtain part time paying jobs; during the war that was worth much to the men themselves and also aided in the war effort.

After the man is measured for his prosthesis, he is put in the group exercise class with amputees of the same type. The prosthesis is not delivered to the patient, but to the walking class, and he wears it under supervision. At the end of the walking class the stump is examined to see if there is skin irritation and any necessary adjustments are made. When he has completed his walking class he is given 30 days leave. He wears his prosthesis home and when he returns, if everything is satisfactory, he is given his discharge. He is then able to take his place in life.

DR. WALTMAN WALTERS, Rochester, Minn.: It was an interesting experience for me to have an opportunity to see and follow the Naval Marine personnel whose battle casualties had necessitated amputations, from the time a few days after the amputations were performed aboard a hospital ship or at one of the advance fleet hospitals, later at intermediate points on their way back to the United States and finally at the U. S. Naval Hospital, Philadelphia.

As has been mentioned, approximately 25 per cent of the amputations were performed because of accidents while on duty. While visiting one of the Fleet Hospitals at Guadalcanal, where one of our members, Doctor Deever, was Chief of Surgery, three patients who sustained crushing blast injuries to their lower extremities from an explosion were brought into the hospital. In two, emergency amputations were performed; on the third, whose condition was too serious to allow use of supportive therapy, an amputation was carried out by refrigerating his extremity.

In the forward areas the amputations had been done by younger surgeons whose Naval medical training had emphasized the safety and value of the guillotine type of emergency amputation necessitated because of battle casualties. I am sure that this accounts for the fact that a relatively small percentage of the patients had open flap types of amputations. Moreover, in Naval warfare, and with the type of evacuation which was necessary, in many instances it was difficult to use any method of applying traction to the skin of the open guillotined stump.

In Philadelphia, the coördinated program of the treatment and rehabilitation of the amputees had been established by Captain C. M. Shaar and was functioning in excellent fashion upon my arrival. The coördinated program has been outlined to you in the abstract of the paper which Doctor Ryan has presented.

In view of the marked reduction in the incidence of infection in cases of reamputation where the stump had been covered either by a plastic revision or skin graft in contrast to patients with open stumps, Doctor White and I were anxious to study the effects of various antiseptic agents upon the bacterial flora of the open stump to see which was the most efficient in promoting more rapid healing of the open stump. The results were described in our paper and need not be repeated.

The correlation of the departments of general, orthopedic and plastic surgery, with the aid of the psychiatrist and the rehabilitation officer, made it possible to employ to the fullest extent in the care of the amputees all the scientific advice available in the treatment of this group of patients. For example, the plastic surgeons assisted us by employing the use of full-thickness pedicle skin grafts to lengthen the soft tissue portion of the ends of some of the short stumps into which bone grafts were later placed to improve the function of the extremity or to permit it to take a properly fitting prosthesis.

The morale of all the amputees was excellent; in fact, they were some of the most cheerful patients in the hospital.

Many of the patients who had had amputations were at the same time victims of additional injuries. These consisted of compound fractures, penetrating wounds of the abdomen and chest, and injuries of the head. Time did not permit a discussion of the treatment of these associated injuries.

The associated service of psychiatry, psychology and rehabilitation were of great assistance in the care of these patients. I am certain that the early fitting of a permanent prosthesis contributed a great deal to the morale. Lessons were given in walking in front of a mirror, dancing and driving an automobile which not only exercised the extremities, but use of the prosthesis could help to restore confidence in being able to walk or to use the arm in a useful fashion. The prostheses were "tailor-made" to order, and were light, durable and efficient. Comments were frequently heard referable to a comparison of the prostheses furnished by the Army and Navy, each extolling the virtue of his own prosthesis, or those of his particular branch of the service, whether Army or Navy.

Lastly, too much credit cannot be given to the group of Naval specialists designated as psychologists, physical therapists, occupational therapists and Red Cross workers who, with doctors and nurses, pooled their knowledge and experience in trying to evaluate those qualities in each boy which would lead him to make an early recovery, adjustment, and return to his former civilian occupation; or to find some other which, by virtue of instruction or training, would fit him to earn a livelihood. An excellent job was done as a result of this correlated care of the amputees.

As the proof of the pudding is in the eating, the follow-up which was carried out in 200 cases of amputees treated at the U. S. Naval Hospital in Philadelphia shows that 78 per cent were either working or continuing their education, and as Doctor Ryan has said—"A permanent lack of adjustment is not necessarily indicated for the group who report no activity, as some of these patients had been discharged only recently and some were taking a well-earned rest."

## THE NEW VIEWPOINT TOWARD SPINAL CORD INJURIES\*

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IN NO PREVIOUS WAR, nor in civilian life, has the patient recovering from the immediate effects of a spinal cord injury been considered particularly a problem. In general, it has been taken for granted that he was a hopeless cripple and that, from bladder infection with its sequelae, his life expectancy was brief. Nursing care and narcotics were in most instances the main treatment. The entire attitude has changed in the past few years. We now know that many of these patients can be cleared of infection and live as long as any one else, that bed sores can be closed with good tissue, that locomotion is possible, and that jobs can be found for them. Many minds have been at work once it was recognized that the previous pessimistic attitude was unwarranted. The team work required to obtain these results as it was developed in the Army needs to be more widely understood.

In World War I 80 per cent died within the first few weeks as a result of catheterization and bed sores. Cushing reported 32 patients with spinal cord damage cared for in the forward areas. Eight were inoperable and all of them died. The other 24 were operated upon and 15 died, a mortality of 62.5 per cent. In World War II rapid and efficient evacuation of the wounded, measures to counteract shock, chemotherapy and greater understanding of nutritional management have combined in restoring to physiologic balance many who would have died early.

In the Army there have been about 1,400 patients with paralysis from spinal cord injury who survived long enough to return to this country. These were divided among about 20 Neurosurgical Centers. While they were considered neurosurgical patients, their care was less from this section than from urology, orthopedics, general surgery, medicine, laboratory and neuropsychiatry. The efficiency of care was in proportion to the team work shown and the ambition of the particular ward officer placed in charge. Few have died since arrival in the United States and these were chiefly in the early days.

1. *Care Abroad.*—The first consideration was speedy evacuation from the front, when possible, to a Neurosurgical Center in the rear echelon. An indwelling catheter, not clamped off, was inserted on the way. The prone position in transit was the most satisfactory. At the Neurosurgical Center in a General Hospital excision of the wound with exploration of the spinal cord was usually undertaken. Several weeks' treatment was then required in preventing and treating urinary sepsis and decubitus ulcers and improving the general condition. Of course, a large proportion of these patients had other complications, *e.g.*, compound fractures, chest and abdominal wounds.

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\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.



If rapid transport from the front was impossible, neurosurgeons at Field or Evacuation Hospitals instituted similar treatment as well as possible. Hyperextension was contraindicated because of the danger of bony fragments being pressed farther into the spinal canal. In the majority of instances a suprapubic cystotomy was done before patients were sent to the Zone of Interior, as a surer method of preventing distention of the bladder during long transport with possible delay *en route*.

2. *Care of the Urinary Tract.*—This is a major concern. In all serious injuries of the spinal cord this is the immediate problem and persists as long as paralysis does. Tidal drainage is the best emergency and definitive treatment. This keeps the bladder free of serious sepsis, maintains normal bladder capacity, and preserves the tone of the muscles of the bladder wall. After three or four months many are able to obtain voluntary control of bladder function and a large majority of those with permanent paralysis establish automatic bladders without clinical evidence of infection. The frequent interchange of fluid in tidal drainage also cuts down the formation of calculi and accumulation of mucus. Various solutions have been used for this, all with enthusiastic advocates. Of course the bladder arriving with a suprapubic opening must heal before tidal drainage is instituted.

Urinary sepsis is combatted by chemotherapy according to the sensitivity of the predominating organism. This sensitivity is gradually lost to the sulfa drugs and much more rapidly to streptomycin. They should, therefore, be used only as urgently required from the clinical, not urinary culture, standpoint until the suprapubic wound is healed and catheter drainage is no longer required. Streptomycin will rid the bladder urine of proteus bacilli in 12-24 hours, but with wounds or foreign bodies in the bladder their number may be as great four or five days later. Sensitivity to streptomycin diminishes rapidly and its use is of no permanent value when suprapubic drainage or a catheter is present. Pyelonephritis will be common if bladder retention is allowed to persist.

The urine must be kept acid and the pH between 4.5 and 5 as prophylaxis against calculi, both bladder and renal. Irrigations with M solution, if tolerated, seem most efficient in keeping stones soft. Bladder calculi are about two or three times as common as renal calculi, and the two combined occur in 20-30 per cent of patients. Routine abdominal roentgenograms are needed at least monthly. Recurring episodes of fever are frequently based on calculus obstruction. Pain is not felt, so does not give us a clue to the situation. Operation for renal calculi is to be avoided as far as possible, since conditions giving rise to calculi will still be present postoperatively. Bladder stones can usually be removed by crushing and evacuating. The treatment of the bladder *per se* is at no time a bar to ambulation, which is of great assistance in improving all aspects of the urologic problem.

3. *Care of the Bowels.*—Frequent digital examinations to rule out impaction are necessary. Mild laxatives should be given occasionally and a slowly administered retention saline enema is given routinely every three days. Chair

## SPINAL CORD INJURIES

patients are taught to maintain latrine habits. A fixture needs to be installed in the toilet so that the patient can lift himself from wheel chair to toilet without assistance.

4. *Supportive Therapy and Nutrition.*—Patients with protein levels below 6-8 grams per cent or hemoglobin below 80 should have transfusions. Hemoglobin and total protein should then be determined weekly, with repeated transfusions given until a normal level has been reached for two weeks. After this the tests should be made on each patient every four weeks. Food must be high in protein content, at least 180 grams daily, and served in an appetizing manner. Food must also be high in calories and vitamins. In extreme nutritional problems gavage or parenteral feeding is employed, using protein hydrolysates and other protein formulae. Unless positive nitrogen balance is maintained, none of the other problems of the patient will progress favorably, notably wound healing and resistance to infection. Even 300 grams of protein a day may be required. The average weight loss in one group of 82 patients between time of injury and arrival in this country was 50 pounds.

5. *The Decubitus Ulcer.*—Over 75 per cent will show ulcers from the size of a silver dollar to that of a dinner plate. These patients must be turned every two hours day and night if on a hospital bed and more often if on a litter or canvas cot. Stryker frames have proved of great value in allowing ready change of position. The formed ulcer is grossly infected with urinary and bowel tract organisms. Excision of necrotic tissue should be performed daily until no more sloughing tissue is present. The ulcer must be isolated by the dressing from continued contamination from feces and urine. With a good nutritional state established, the ulcer shows progressive spontaneous healing. With the ulcer healed, positive nitrogen balance is often rapidly attained, whereas it was difficult or impossible to maintain previously. The scar of spontaneous healing or a split-thickness graft tends to break down frequently with formation of new ulcers. For these reasons and because the necessary early ambulation is impossible with a large decubitus ulcer, surgical closure has proved most desirable and a tremendous time-saver. Full-thickness flaps of skin and subcutaneous tissue from adjacent surfaces of any required extent are rotated to fill the defect. Atrophy of the glutei muscles usually leaves an abundance of loose skin to be borrowed from the buttocks. Before operation the floor of the ulcer must be covered with healthy granulations and the margins must be fixed with growing epithelium. At operation the ulcer is completely excised including both the peripheral rim of scar tissue and the granulating base. Undermining and shifting is then done to any extent necessary. Nonabsorbable ligatures and sutures are used throughout with a most meticulous closure. The results have been excellent with healing usually within two weeks.

6. *Ambulation.*—The chief desire of the patient is to be able to walk again. Every effort must be made to see that this desire is fulfilled. The entire exercise program is planned with this end in view. Exercises of the upper extremities and shoulder girdles are commenced while confined to bed, are continued

when allowed in a wheel chair and are transferred to a mat as soon as the patient is able. Power of abdominal and back muscles must be increased also. For a life of crutch-walking the unaffected muscles must be especially developed. Before the patient can stand or attempt crutch-walking he must be custom fitted with bilateral lower extremity braces, frequently extending no higher than the upper femoral region. They must be light, but strong enough to give confidence. They must immobilize his knee joints and not allow his feet to drag. They can be made so that a pair of braces with shoes without a pelvic band weighs three pounds for each extremity.

Physical therapy is necessary for the lower extremities from the first. One seldom knows that complete paralysis will persist. Passive exercise of lower extremities is given for reeducation. There may be a flicker in some muscles and continued guided exercise of these may later allow a change from a long caliper to a foot drop brace only. Functional activities, *e.g.*, shaving, putting on socks and slippers, are required from the time a patient is able to sit erect and balance himself.

The patient graduates from mat exercises for upper extremities and trunk to standing exercises in parallel bars and crutch-balancing exercises. Next comes actual training in ambulation with crutches and braces. Two gaits are taught—the “step-through” and the “swing-through.” The “step-through” is much harder to learn, but gives the appearance of more normal locomotion. The “swing-through” can be learned readily after the other is mastered and the patient can then use either which seems to fit his needs at the moment best.

Having learned to rise from bed to chair, from chair to standing position, from this to crutches and then to negotiate curbs and steps, the next instruction is in driving an automobile with hand controls. State motor vehicle bureaus are giving licenses to these men after examination. Throughout this whole exercise program a chart is kept showing the time of accomplishment of each of some 60 achievements. The possible morale factor in arousing competitive spirit in this way is evident. Success in ambulation is a great aid to practically every other problem of the paraplegic.

7. *Pain.*—From a third to a half of these patients will have some form of unpleasant sensory disturbance more or less persistent. Narcotics should be denied as much as possible because of habit-forming effects. Pain may be a tingling sensation, moderate or agonizingly severe root pain of segmental distribution, or of a causalgia type usually in one extremity only. Pain tends to decrease spontaneously with time and improvement in general condition and activity. But in a certain number, probably less than ten per cent, pain has been persistent or severe enough to require surgical intervention. Posterior rhizotomy, nerve root section, has been applicable, particularly in cauda equina lesions, and because it preserves all possible nerve function. The sensory roots are often found at operation glued to cord or dura by dense adhesions, partly torn, or adherent to rough spicules or fractured bone. Cordotomy, section of one or both lateral spinothalamic tracts, should generally be reserved for the

most severe cases not relieved by rhizotomy. With evidence of causalgia lumbar sympathectomy is of course the choice.

8. *Spastic Contractions*.—These have first appeared at intervals of from two weeks to seven months after injury. In one series of 41 lesions of the thoracic cord 80 per cent had spasm, and, in general, this condition appears in about 40 per cent of the entire group. Spontaneous improvement occurs in many when they become ambulatory and operation should be done only in those with such severe spasm that ambulation is impractical. If the cord lesion is complete, an attempt should be made to make the patient ambulatory by the simplest possible procedure, *e.g.*, section of the obturator nerve for adductor spasm. If unsuccessful, intrathecal alcohol or anterior rhizotomy should be considered. If the lesion is incomplete there should be delay of at least one year after clinical improvement has ceased before any destructive operation is done.

9. *Psychologic Readjustment*.<sup>1</sup>—A spinal cord injury usually occurs suddenly. With its violent reception there is an instantaneous change in the state of the individual from one of independence to almost complete dependence on others for transportation, nourishment and disposal of body excreta. The adult suddenly returns to the infantile state. Depression, even with thought of suicide, is the common initial reaction. A period of expectation that his legs will move again follows, often fostered by misguided statements of those around him. With his physical dependence he becomes less mature emotionally also, as shown by irritability and fits of anger. He becomes fearful of everything—being a burden, having to leave the hospital, having to earn a living. He deceives himself into thinking that time will result in complete recovery of his lost functions. At some time the extent and permanency of his condition has to be explained to him. Then he must be told the things he can do in the future within the limitations of his handicap. He must also be shown this by having the opportunity for actual training in suitable vocations. His psychologic rehabilitation needs to be carefully handled coincident with his physical rehabilitation.

In trying to accomplish this the services of the American Red Cross, Occupational Therapy, and the educational and shop programs have played a large part. Recreation, particularly of the type in which he takes an active part, training in arts and skills, helping in adjustment to his family, giving the patient an opportunity to explore his potentialities both for an occupation and for hobbies, all play an important part in readjusting the man to his incapacity.

What does the future hold for these men? Their rehabilitation must be continued with the use of great imagination. Otherwise they will be "merely living memorials to the skill of medical officers during World War II, but to no good purpose. They must be given something beside just the privilege of staying alive."<sup>1</sup> The value of this work to us is that in the occasional similar patient we come across in civil life, we shall appreciate the many facets of the problem to be considered and the variety of specialists needed in each instance.



Patients with spinal cord injuries may be helped in a multitude of ways. Preservation of life, at least, is no longer hopeless.

## REFERENCE

- <sup>1</sup> Thom, Douglas A.: Personal communication.

DISCUSSION.—DR. CONDUCT W. CUTLER, JR., New York City: "A defeatist attitude is intolerable in the care of patients with traumatic transverse myelitis."

This opening statement of Technical Medical Bulletin No. 162, issued by the War Department in May, 1945, sets the standard and suggests the program for the treatment and rehabilitation of patients with spinal cord injuries.

There is little one can add to Doctor Kennedy's careful presentation of this program and its results. One can only affirm the effectiveness of the plan and add some further observations on particular phases of the problem.

At the close of hostilities, there were 88 patients with cord injuries under treatment at the Cushing General Hospital. At the time of their reception they were emaciated, anemic, with evidence of profound avitaminosis, incontinent of feces and with suprapubic cystostomies, afflicted with large decubitus ulcers, and in a low state of morale. By means of transfusions, proper alimentation, and vitamin medication, their general condition was rapidly restored to as nearly normal as possible. Attention was given to the proper clearing and attempted control of the bowels, and an intensive program was undertaken for the elimination of urinary infection and establishment of automatic bladder.

At first it was thought necessary to keep these patients in bed during treatment of their bladder conditions and to maintain the suprapubic cystostomies for long periods. Later it became apparent that they could be out of bed earlier than was previously thought possible and that the suprapubic drainage could be replaced by urethral catheter at an early date. The suprapubic drainage tubes were removed as soon as gross infection of the bladder had cleared up under irrigation. Suprapubic sinuses failing to close within two weeks after removal of the suprapubic catheter were surgically closed. Irrigations of the bladder at two-hour intervals were continued through the urethral catheter until cystometric examination revealed increasing capacity. At this time tidal drainage was instituted and was continued until automatic bladder function had been established. Roentgenologic studies were made regularly to discover any existing stones.

In the management of decubitus ulcers, we ran the gamut of local treatment, hoping to secure a separation of slough, clean granulation, and perhaps epithelization. Progress toward healing was slow under all types of local application.

Grafts of various sorts were tried, with little to choose between them in point of effectiveness. Eventually, it was discovered that it was possible to close some of these ulcers effectively by suture. This came to be the method of choice wherever it could possibly be employed.

The ulcer was excised with complete undercutting of the skin and subcutaneous tissue with the formation of wide flaps. Closure of the defect was performed with tantalum or steel wire suture. Two layers were employed in closure, one for the deep fascia and one for the skin. The stitches were left in place for 21 days. Penicillin was used systemically both pre- and postoperatively. This plan of attack virtually superseded other methods of closure and sacral decubitus ulcers as large as 15 centimeters in diameter were successfully closed and healed. Of 52 such operations reported in our first group, 60 per cent of the bedsores closed by suture remained healed on the first attempt.

Regular exercising of the unparalyzed muscles of the upper body was carried on assiduously from the start, and as soon as the bladder and ulcer condition permitted, the patients were given special instructions in self-care and in walking. The orthopedic



## SPINAL CORD INJURIES

section collaborated in the construction of appropriate braces and, with these applied, the patients attended classes daily for guidance, assistance and instruction. Special wards and messing, exercise, physical therapy and recreation facilities were provided for these patients, and an active program of rehabilitation, including work projects, was maintained.

Observations on a group of 67 patients suffering from spinal cord injuries were reported by the Neurosurgical Service. Three had cervical spine injuries, 46 dorsal spine injuries, and 18 lumbar spine injuries. Twenty-five per cent had incomplete paralysis with sufficient motor function of the legs to permit walking with braces. Only two of the complete paraplegia cases were of flaccid type. Twelve patients presented complete sympathectomy effects. Twenty showed increased sympathetic tone (with cold, moist feet). All but one had flaccid paralysis of the bladder. Three patients with priapism had contusion rather than transection of the cord. No case which on admission showed no flicker of motion in the foot or leg showed any improvement after one year of hospitalization. Only two cases of cauda equina injury which showed no flicker of motion on admission showed later improvement. In these 67 cases of paraplegia, 34 laminectomies had been done overseas, while 14 laminectomies were done in Cushing Hospital because of total manometric block or in order to determine prognosis and the justification for anterior root resection to diminish spasm. In these 48 cases subjected to laminectomy, the following findings were recorded: 14 cases, transection; 18 cases, normal appearing cords; 16 cases, contused cord.

Sixteen patients eventually improved and sufficient function developed to permit walking. The remainder showed no neurologic improvement in from one to twelve months. Yet even those who showed no neurologic improvement were brought to a tolerable and even a useful existence. In this significant fact lay the justification and the reward of the new attitude toward spinal cord injuries.

DR. LOYAL DAVIS, Chicago, Ill.: Doctor Kennedy has given an excellent description of the fine care which the paraplegia patients have received in Army hospitals. I can corroborate all his statements because I had the opportunity, after returning from overseas, to visit seven Neurosurgical Centers at the request of the Surgeon-General. In each place these patients received meticulous attention to every detail of their treatment and the Army Medical Corps assigned trained personnel whose duty it was to devote themselves to the care of these patients. For example, at one of the General Hospitals there were doctors, physical therapists, nurses, entertainers, and orderlies in such number that for each patient there was an average of one person with him throughout the 24 hours.

Now these patients have been transferred to the Veterans Administration, and rightly so, because they are, and should remain, wards of the Government. The advancement and knowledge of the surgical profession in the past 25 years has been so great that these patients have been kept alive, whereas in the last war they died. However, it must not be concluded that when they are discharged from the Army hospital to the Veterans Administration they are custodial cases. As a matter of fact, they are patients who will always require the most meticulous, painstaking and personal care. They will always be medical and surgical problems; they will develop decubitus ulcers, urinary bladder stones, urinary infections, and depression, unless they receive the same amount of care that they have had in the immediate past. The doctors of the Veterans Administration and the profession at large know how to treat these patients just as well as the Army has treated them, but the problem is to find personnel to give this care. Nurses, attendants, physical therapists are just as difficult to find for the Veterans Administration as they are for private hospitals. At the Veterans Administration Hospital at Hines, Illinois, where more than 300 patients have been transferred from the Army, it has been necessary to ask the Surgeon-General to transfer to Vaughan Hospital the personnel who can look after these patients with the same

standards of efficiency, until the Veterans Administration can supply personnel, which also includes doctors.

I believe that this is important, because the profession and the laity must be aware of the tremendous duty it has to these patients and because it is so easy for those who are politically minded to criticize the care of these patients in the Veterans Administration without knowing or attempting to find out the difficulties encountered in obtaining personnel to look after them. Finally, the profession and the laity must understand that not all patients who are paraplegics can be made to walk again. What can be done depends entirely on the level and the nature of the spinal cord injury. Unfortunately for these patients, the psychotherapy necessary for them has been over-emphasized and over-sold, to the point where there may very well be a very disturbing and bitter reaction upon the patient and his relatives.

DR. HOWARD C. NAFFZIGER, San Francisco, Calif.: The Army and Navy deserve great praise for the encouragement that has been brought to these most severely injured patients.

Much publicity has been given to ambulation and the benefits to the patients have, no doubt, been great. Ambulation for those with incomplete cord lesions or those with damage to low levels is in a different category from the complete lesions at the midthoracic level, or higher. In the latter, the benefits of ambulation are indirect ones. Strengthening of the musculature in the trunk and upper extremities, improving nutrition, and promoting psychologic adjustment to their situations have been promoted. In the group of those with high complete lesions, yet with intact innervation in the upper extremities, I should like to stress the importance of early occupational guidance. Experiences with such patients who have become self-supporting have emphasized its value. Occupation and restoration of earning power are prime factors in management.

DR. WILLIAM JASON MIXTER, Boston, Mass.: I have had a certain amount of experience in seeing these cases for the Surgeon-General, and it has been interesting to watch the advance in the care of paraplegics in the last three years. We were pretty badly discouraged at first. I believe a great deal can be done to help these patients. We have heard a good deal about the question of anterior root section for spasticity. This is a very valuable adjunct in treatment. But it is extremely important that anterior root section be withheld until we are perfectly sure there will be no return of power in the muscles.

DR. JOHN H. GIBBON, JR., Philadelphia, Pa.: I merely want to emphasize one point Doctor Kennedy did not have time to discuss—the psychologic readjustment of the patient to his physical condition. This readjustment is of great importance to the problem of nutrition. A man will not eat until he feels that the future holds something for him. Until the patient is convinced that life holds some promise of a place where he can be reasonably happy you are really licked on the problem of nutrition. There are two ways of getting psychologic readjustment rapidly. One is through the personality of the family doctor or the ward officer in the Army hospitals. If you have a doctor who is not interested and cheerful and encouraging you will not get to first base. If you have the right family doctor, patients will make the proper adjustment quickly. The second way of helping these patients is to use as an example one of the patients who has already become adjusted. We had one such patient in a large ward of paraplegic patients. He did more than anyone else, not excepting Gray Ladies, Red Cross, *etc.*, to improve morale. He went outside the hospital and worked at a mechanical job in a small plant for two hours every day. He thus gave a practical demonstration that a man with paralyzed legs could hold down a job. His cheerfulness and determination gave an enormous boost to the morale of the other patients.

## SPINAL CORD INJURIES

DR. ROBERT H. KENNEDY, New York City (closing): Regarding the future problems of the veterans, I think nothing can be certain as yet. Many who now wish to go to their homes are going to find that they would prefer to remain in communities where there are others with similar injuries. Parents are anxious to have these men at home at first. In one Center with 130 patients, already about 40 have gone to their homes. This hospital expects to close June 30, and in the meantime they expect to have 30 more ready to go home, which will leave about 60 to transfer to Veterans hospitals. This shows the result of training. They are all given periods at home for at least a month before they are discharged, so that they may learn whether they wish to stay at home and that their families may know whether they want them.

So far as occupational therapy is concerned I think it is extremely important. I was much interested at one hospital in a factory for precision work. The men were allowed to work two hours in the morning and two in the afternoon; they had to punch a time clock and were docked if they were late. They were paid by the hour, and it was amazing to see the interest they took. Of course, that does not solve the problem later. I agree with Doctor Mixter that one has to wait at least a year before doing any destructive operation, not knowing how much return of function there may be.

## OPERATIVE RESULTS IN INTERVERTEBRAL DISKS\*

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PRIOR TO 1930, pain in the lumbosacral region radiating down the leg was commonly termed sciatica or sciatic neuritis. With rest in bed, heat, leg-traction and other conservative methods, many patients recovered satisfactorily. Gradually the pain subsided, they resumed their original occupation or changed to lighter work, and, on the whole, did not do too badly.

The discovery that a sudden twisting injury to the lower spine could rupture the intervertebral disk, protrude it posteriorly, and, by stretching the underlying dura and compressing adjacent nerves, produce this low-back pain sciatic syndrome, cleared up at once the obscure etiology of many of these cases. Consequently, surgical removal of the disk was promptly suggested and widely heralded as the most certain means of assuring rapid and complete relief. Although the pain accompanying a ruptured disk can vary from decided discomfort to extreme distress, the condition of itself never resulted in a fatality. To advise surgery under these conditions, even when the operative procedure is as safe and simple as that required in the removal of a disk, brings up the definite question as to the expediency of operative intervention. With even the simplest surgery, unfortunate accidents can, and have, occurred. Following operative removal of the disk, will the patient be relieved of his discomfort so that he can return to work? What are the chances of failure to relieve the pain, or of an increase of disability, following surgery? It is high time that more emphasis be laid upon follow-up results after operation, than upon diagnostic methods and surgical technic.

While the literature is replete with information dealing with clinical signs, diagnostic methods and operative technic, but little is said about results.

A review of the literature reveals relatively few summaries of post-operative results. Verbrugghen<sup>1</sup> records 83 per cent successful in 75 cases. Shinnars and Hamby<sup>2</sup> in 87 cases claim 50 per cent cured and 50 per cent with some residual pain in back or legs. Poppen<sup>3</sup> reports 65 per cent of 400 cases completely relieved, 35 per cent improved, although in 90 per cent of this latter group the sciatic pain was checked. In 60 per cent of his cases postoperatively, heavy lifting brought on low back discomfort. Jelsma<sup>4</sup> describes 90 per cent good results in 150 cases operated upon. Botterell and Keith,<sup>5</sup> and Gross<sup>6</sup> in handling military personnel were able to return 60 per cent and 70 per cent, respectively, to full duty. McKenzie and Botterell<sup>7</sup> in 57 cases report 48 excellent and nine fair results. Barr and Mixter<sup>8</sup> showed 77 per cent complete relief. In Camp and Love's<sup>9</sup> series, 66 per cent of 50 cases showed a highly satisfactory result. Craig and Walsh<sup>10</sup> differenti-

\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

ate their results in compensation and noncompensation cases, a highly important point. In noncompensation cases, in 83.3 per cent results were satisfactory as against 59.1 per cent in the other group. Adson<sup>11</sup> in making the same separation rated 90 per cent of his noncompensation group as satisfactory, the percentage falling to 77 per cent in the compensation cases. Keegan and Finlayson<sup>12</sup> show, roughly, 75 per cent satisfactory and 25 per cent poor results. Smith and Deery<sup>13</sup> in 70 cases record 34.3 per cent excellent and 45.9 per cent good results. So it can be seen that while, by and large, the results are fairly successful, nevertheless, the surgical removal of a ruptured disk does not necessarily result in complete relief of pain.

Pain produced by a ruptured disk has two components, the pain in the back and the pain in the leg. Back pain is the initial complaint followed by pain radiating down one leg. Leg pain in the sciatic distribution leads to the suspicion or certainty of a ruptured disk. Pain in the back is due to pressure on, or rupture of, the posterior vertebral ligaments. Pain down the leg is caused by the protrusion of the disk against the adjacent lumbar nerve roots. These two pains are different components of the same progressive picture, and both are important in its recognition. Why does the disk rupture? Trauma, a twisting wrench of the lumbar vertebra, is a commonplace finding in many histories. But in other instances, a no more serious injury than rolling out of bed has been noted. Does the disk rupture because of some structural disability of the back and is the low back pain the earliest clinical evidence of such weakness? This point, I believe, is very important, because while by removal of the disk the leg pain is almost always relieved, the pain in the back may remain and produce discomfort and disability.

It is necessary to state here that, while we are convinced that these two pain components exist and for different reasons, as outlined, we have had no experience with fusion as a means for relief of the back pain following improvement or relief of the leg pain by removal of the disk. It is hoped that the indications for, and results of, fusion will be one of the points brought out in the discussion.

This paper deals solely with the results following surgical removal of an abnormal intervertebral disk in 200 cases. The follow-up period varies from 6.5 to 1.5 years, with an average of just over three years. No case operated upon since January 1st, 1945, has been included, so that sufficient time has elapsed to determine with some accuracy the final result. These 200 cases represent replies to a questionnaire sent out to 275 cases. In addition to the questionnaire, some 150 cases reported in person.

In reviewing these 200 cases, attention was centered solely on one group of facts; what was the patient's condition prior to surgical intervention and to what extent was he benefited by the operative procedure. Preoperatively, 72, or roughly 35 per cent, were suffering so much back and leg pain that they were bedridden; 104, or 55 per cent, were unable to work and 24, or 10



per cent were working, although under considerable distress. As a result of surgical procedures, the following results were noted. One hundred and twenty-seven cases, or roughly 63 per cent, were completely relieved of all pain; 58, or 29 per cent, were improved and 15, or 8 per cent, were unimproved or worse. Since the type of work which these patients were performing when the injury to the back occurred, and especially the occupation they must resume postoperatively, and the amount of strain to which the lumbosacral area will be subjected is of critical importance in estimating the ultimate outcome, these figures were further broken down. Among these 200 cases, 98 were laborers: miners, farmers, shipbuilders, nurses, and 102 were nonlaborers: clerks, executives, professional men, housewives. Interestingly enough, the division between laborers and nonlaborers is nearly equal. Hard labor, of itself, does not seem to be a predisposing cause for ruptured disk. In the group of 98 laborers, 57 were completely cured, 57 per cent, 37 were working with some disability or had changed to lighter work, 37 per cent, and four were unimproved, 4 per cent. Among 102 nonlaborers, 69 were entirely relieved, 68 per cent, 20 improved, 20 per cent, and 13 unimproved, 12 per cent.

What is the effect of the degree of protrusion of the disk; complete rupture, simple protrusion or the so-called hidden disk, upon the operative results? A definition of what is meant by these three varieties of disk is indicated. Frequently a disk is exposed which has actually commenced to extrude itself into the canal, so that without incision of the annulus it may be seized and withdrawn, or the nerve may be humped over it and retraction of the nerve to either side is followed by an immediate greater or smaller amount of protrusion. This is our conception of a completely ruptured disk. Secondly, a protruded disk represents a situation where the annulus is obviously protruded posteriorly by the disk, and when once the annulus is opened, prompt spontaneous emergence of the disk occurs. Lastly, a hidden disk produces little or no protrusion of the annulus, although the overlying spinous process shows an increased mobility, the adjacent root is slightly swollen, and palpation over the annulus reveals some relaxation. Incision of the annulus and curettage of the disk suggests that softening and degeneration have occurred.

In this series of 200 cases, 49 had a cleanly ruptured disk; 26 laborers, 23 nonlaborers. Twenty, ten laborers and ten nonlaborers, were bedridden by the pain; 23, 13 laborers and ten nonlaborers, were unable to work and six, three from each group, were working with some disability. Forty-two myelograms were carried out in this group and all showed definite evidence of the presence of a disk. Following removal of the disk, 39, 80 per cent, 20 laborers and 19 nonlaborers, are completely relieved; nine, six laborers and three nonlaborers, are completely relieved of leg pain, 18 per cent; but have in eight cases occasional slight, and in one, moderately severe back pain, while only a single patient is entirely unimproved, 2 per cent. In an average follow-up of 3.6 years, a single case has had recurrence of pain.

## INTERVERTEBRAL DISKS

One hundred thirty-one patients had protrusion of the disk, 65 laborers and 66 nonlaborers. Forty-seven, 21 laborers and 26 nonlaborers were bedridden. Sixty-nine, 36 laborers and 33 nonlaborers, were unable to work, and 15, eight laborers and seven nonlaborers were working with some disability. Following removal of the disk, 77, 35 laborers and 42 nonlaborers, were entirely relieved of pain, 59 per cent; 44, 28 laborers and 16 nonlaborers were completely relieved of their leg pain, 34 per cent, but 18 of the 28 laborers had shifted to lighter work because of renewed back pain, and six of the 16 nonlaborers had occasional periods of lumbosacral discomfort. Ten patients, three laborers and seven nonlaborers, were unimproved, 7 per cent. In an average follow-up of this group of 3.5 years, five patients, three laborers and two nonlaborers, have suffered a recurrence of pain similar to their original attacks.

Twenty patients had "hidden" disks, eight laborers and 12 nonlaborers. Six, two laborers and four nonlaborers, were bedridden, 12, six of each group, were unable to work and two nonlaborers were working with some disability. Following surgical intervention, 11, three laborers and eight nonlaborers, were completely relieved, 58 per cent; four, three laborers and one nonlaborer, had occasional disability, 21 per cent; and five, two laborers and three nonlaborers, were not relieved, 21 per cent. In an average follow-up of four years, two nonlaborers returned with definite evidence of a recurrence.

Broadly speaking, our figures seem to confirm the impression gained from clinical experience that the greater the amount of preoperative pain, the better the final result. It is also interesting to note that of the 17 failures, nine had had but one attack of pain prior to operation. At present, no patient suspected of having a ruptured disk is considered for operation unless he has had two attacks or more of pain and unless the pain is severe at the time he presents himself in clinic. To operate upon a patient who has had his attack and whose pain is definitely receding is unwise. All these persons will have some distress for a longer or shorter period postoperatively. If they have had a great deal of pain preoperatively, this postoperative readjustment period means little to them. Their major pain is relieved and the mild postoperative pain is readily accepted. But if the preoperative pain is mild, particularly if the surgeon has been unwise enough to promise complete relief, then this postoperative pain discourages them; they feel the operation has been a failure and the final result is much less satisfactory.

In the course of this review, two other groups of cases were encountered, 29 patients operated upon for disk in whom no disk was found, and 44 cases in whom, who although clinically, and in 33 further confirmed by myelography, an intervertebral disk seemed unquestionably present, for various reasons no operative procedure was carried out. In the operated unverified group of 29, 17 were laborers and 12 nonlaborers. Nine were bedridden, 17 unable to work and three were working with difficulty. Following operative exploration without removal of a disk, 14, ten laborers and four nonlaborers, were entirely relieved, 48 per cent, eight were working with some disability

or changed to lighter work, 28 per cent, and seven were unimproved, 28 per cent. These figures parallel very closely the "hidden disk" group, into which category it seems quite possible that many of these cases might well fall. The average follow-up was four years, and none, as far as is known, has had a recurrence. The disk suspects unoperated comprise 44 cases, 21 laborers and 23 nonlaborers. Thirteen, four laborers and nine nonlaborers, were bedridden; 15, ten laborers and five nonlaborers were unable to work, and 16, seven laborers and nine nonlaborers were working with disability. Under conservative treatment only: ten, three laborers and seven nonlaborers were completely cured, 23 per cent; 18, ten laborers and eight nonlaborers, were improved sufficiently to work at lighter jobs, 41 per cent; nine comfortably and nine with occasional mild pain, and 15, ten laborers and five nonlaborers, were unimproved, 36 per cent. Three of these last patients were operated upon elsewhere some time within the four-year average follow-up for this group.

That in all of the patients in this nonoperated group, a recurrence, or severe increase in pain, can occur at any time, if they are unlucky enough to twist or wrench their backs, is of course admitted. Removal of the disk may then be carried out. Although this is a relatively small group of cases, that recovery has occurred under conservative treatment alone should be remembered.

As a result of this review of the results of the surgical removal of a ruptured disk, we see no reason to change the conservative attitude we have adopted in the past years. Pantopaque myelography should always precede operation to show the size and position of the disk and whether more than one exists. Curiously enough, we have never seen a double disk, although Dandy<sup>13</sup> has stated that they are not uncommon. If myelography shows a large disk, if the pain is severe, and if the patient has had previous attacks, surgical removal of the disk is indicated. But surgery is not, in our opinion, the only treatment for this condition. The question as to whether surgery is expedient should always be considered. Many of these patients will recover with rest, leg traction, a back brace, and other nonoperative methods. Nature will care for many of these sufferers exactly as was the case prior to 1930. It seems presumptuous of the surgeon to interfere until he has given nature every chance. The results from surgical treatment do not seem sufficiently good to warrant it.

## REFERENCES

- <sup>1</sup> Verbrugghen, A. H.: Herniated Nucleus Pulposus: A Report of 75 Cases Examined and Operated. *Dis. Nerv. Syst.*, 4, 165, 1943.
- <sup>2</sup> Shinnars, B. M., and Hamby, W. B.: The Results of Surgical Removal of Protruded Lumbar Intervertebral Disks. *J. Neurosurgery*, 1, 117-122, March, 1944.
- <sup>3</sup> Poppen, J. L.: The Herniated Intervertebral Disk: An Analysis of 400 Verified Cases. *New Eng. Jour. Med.*, 232, 211-215, February 22, 1945.
- <sup>4</sup> Jelsma, F.: Clinical Analysis of 1,000 Consecutive Cases of Low Back Pain. *South. Med. Jour.*, 37, 372-78, July, 1944.

- <sup>5</sup> Botterell, E. H., Keith, W. S., and Stewart, O. W.: Results of Surgical Treatment of Sciatica Due to Herniation of Intervertebral Disk in Canadian Soldiers Overseas. *Canadian M. A. J.*, **51**, 210-214, September, 1944.
- <sup>6</sup> Gross, S. W.: Protrusions of the Intervertebral Disks in Military Practice. *Trans. Amer. Neurol. Assoc.*, **69**, 119-123, 1943.
- <sup>7</sup> McKenzie, K. G., and Botterell, E. H.: The Common Neurologic Syndromes Produced by Pressure from Extrusion of an Intervertebral Disk. *Canad. Med. Assoc. Jour.*, **46**, 424, May, 1942.
- <sup>8</sup> Barr, J. S., and Mixter, W. J.: Sciatic Pain in Low-back Derangements: Its Incidence, Significance and Treatment: Symposium; Posterior Protrusion of the Lumbar Intervertebral Disk. *J. Bone and Joint Surg.*, **23**, 444, April, 1941.
- <sup>9</sup> Love, J. G., and Camp, J. D.: Root Pain Resulting from Intraspinal Protrusion of Intervertebral Disks: Diagnosis and Surgical Treatment. *J. Bone and Joint Surg.*, **19**, 776, July, 1937.
- <sup>10</sup> Craig, W. McK., and Walsh, M. N.: The Present Status of the Protruded Disk Syndrome. Read before the meeting of the International Congress of Neurologic Surgeons, Copenhagen, Denmark. August 21-25, 1939.
- <sup>11</sup> Adson, A. W.: Technic of Removal of Protrusions of Intervertebral Disks. *Am. Acad. Orthop. Surg. Lect.*, **111**, 120, 1943.
- <sup>12</sup> Keegan, J. J., and Finlayson, A. L.: Low Back and Sciatic Pain Caused by Intervertebral Disk Herniation. *Nebraska Med. Jour.*, **25**, 179, May, 1940.
- <sup>13</sup> Smith, A. DeF., Deery, E. M., and Hagman, G. L.: Herniation of Nucleus Pulposus: A Study of 100 Cases Treated by Operation. *J. Bone and Joint Surg.*, **26**, 821-828, October, 1944.
- <sup>14</sup> Dandy, W. E.: The Treatment of Recurring Attacks of Low Backache without Sciatica. *J. A. M. A.*, **125**, 1175-78, August 26, 1944.

DISCUSSION.—DR. WILLIAM JASON MIXTER, Boston, Mass.: In the first place, I should like to thank Doctor Grant for bringing up this subject at this time and for giving us a very keen evaluation of his results, and for asking certain questions which, at the present time, I do not think we are able to answer. So far as I know there has been no complete study made of the results on a large group of cases of intervertebral disk, carrying out the criteria he has asked for. I think we are all trying to carry that out at the present time, and hope the answer will be forthcoming. We may be able to answer that question at the meeting of the Orthopedic Association next June, when the problem is to come up again. I think we must depend to a considerable extent on the Army and Navy for evaluation of the problem of ruptured intervertebral disk. The enlisted man has been a very unsatisfactory patient upon whom to do surgery.

There are one or two points to mention. Doctor Grant says this operation is done for relief of pain and that no fatalities have occurred from letting patients go. Fatalities do occasionally occur from letting patients go, because they get an acute transverse lesion which results in death from sepsis unless relieved. Patients have paralysis and foot drop if the lesion is allowed to persist for any length of time, and the foot drop does not come back.

I cannot answer the question about fusion. We are looking up these cases at the present time, and we have in Boston a more or less parallel series and may be able to answer some of the questions. My own impression is that patients who have to do heavy work, laborious work, postoperatively, and where there is definite and abnormal mobility demonstrable at the time of operation, probably should have fusion done. Doctor Grant's criteria for operation I believe are accurate and I would subscribe to them. I would also subscribe to the dictum not to operate upon patients who are recovering from an acute attack and are pretty well. They are better operated upon in an acute attack. I believe that real ruptured disks with extrusion are the ones in



which you get the best results. The patients with a bulging disk margin or softened disk margin do not give nearly so good results.

DR. GEORGE E. BENNETT, Baltimore, Md.: Last evening Doctor Grant handed me a copy of his paper and, after reading it and listening to his intelligent discussion, I believe it is about the most sane presentation of this important subject that I have yet read or heard. There are, without question of doubt, a great many cases of sciatic pain associated with intervertebral disk injury which demand operation, and the end-results are very satisfactory. There is another group of congenital abnormalities of the facets with secondary degenerative change in the intervertebral disk and subsequent nerve pressure, which require not only removal of the débris in the spinal canal but also a fusion of the vertebral bodies in order to effect a cure. There are also a great many cases of sciatica which are not the result of pressure on the nerve root from degeneration of the intervertebral disk, such as in Strümpell-Marie arthritis, where the change is about the facet with associated pressure from inflammatory reaction, which usually clears up with time.

Many years ago in discussing this subject with Doctor Mixter I asked him the indications for operation. His reply was: "After you have tried all the orthodox methods of treatment for sacro-iliac strain and lumbosacral lesions and your patient is not relieved then you should consider an intervertebral disk, and after thorough study operation might be suggested."

I feel that Doctor Grant has posted a sign such as we see at a railroad crossing—"Stop, Look and Listen!"

DR. JAMES C. WHITE, Boston, Mass.: It may be of interest to summarize a series of 24 sailors and marines who had lumbar intervertebral disks removed at the U. S. Naval Hospital in Chelsea, and were then carefully followed for from six months to two years. So far as I know, there are practically no studies on military personnel who have had this operation. The Bureau of Medicine and Surgery of the Navy was extremely coöperative and followed-up these patients all over the world. Of nine officers returned to active duty, eight have remained in this status to date. One who fell in a foxhole and gave his back a wrench came back subsequently to the hospital needing a spinal fusion, which was done. Of 24 men and officers, 75 per cent, after periods of over five months, were on full duty or on limited duty with the expectation of returning to full duty; of the remaining 25 per cent, one has been a total failure and fusion has not helped. Two have returned to the hospital with recurrence. Both of these men had been doing too heavy work, one shoveling snow and the other handling heavy mess trays. Two others were last heard from on limited duty but not completely free of symptoms. So you have about 75 per cent in whom it looks as if the operation had been effective from a military standpoint. They all had preliminary orthopedic treatment and were submitted to us after that had failed. Only definite disks were operated upon and the more definite the disk the better the result. One had an obstructive disk with paralysis of the bladder; he was a football player, and he played football three weeks later, unknown to me. He has done well. In contrast, in another hospital where we could not give as satisfactory preliminary orthopedic treatment, the results, I am sure, are not going to be so good.

DR. PHILIP D. WILSON, New York City: There are many aspects of this problem that could be discussed, but I should like to speak only on one or two points. In the first place, I believe that myelograms are generally helpful in dealing with fresh cases. Since pantopaque has been made available to civilian hospitals we have had excellent results in employing it and have always been able to remove it afterwards through the needle. If this technic is followed I do not believe that it could be harmful, and we need all possible information not only in making the diagnosis, but also in localizing the lesion. I have seen a good many cases, however, that have been operated upon



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previously, where the disk has been removed, without relief of symptoms. In such cases I believe that the myelograms may be very deceptive and that old extradural adhesions, together with the absence of the ligamentum flavum, may distort the picture. I think this point should be borne in mind in making studies on such cases.

The second point is as to the place of the fusion in treatment of disk protrusion. Should fusion be done in every case in which the disk is removed? I do not think so. There is no doubt that when we combine fusion with disk removal we increase the severity of the operation. We have to secure a much larger surgical exposure for such a procedure than when the disk alone is removed, and, in addition, there is always prolongation of convalescence required by the necessity of having to immobilize the spine in order to obtain solid fusion. I believe that fusion should be done when there are associated spinal lesions which of themselves might produce symptoms, and I think fusion should also be done when we fail to find a satisfactory explanation of the pain after inspection of the disk; otherwise, I believe fusion should be reserved as a secondary procedure to be done when disk removal fails to give relief. From Doctor Grant's figures we can see that this group of cases is going to be relatively small. Furthermore, I believe that in the cases where we find a soft bulging disk without actual protrusion, fusion should be done. I cannot believe that even complete curettage of the disk will be followed by such complete fixation of the adjacent vertebrae as to guarantee freedom from pain. I have made roentgenologic examinations of several cases in which this procedure has been done by able surgeons and, by taking films in flexion extension, or in different positions of lateral extension, have been able to demonstrate that motion still existed between the two vertebrae. This motion was limited, to be sure, but not sufficiently so to prevent pain.

I believe that it is important for the orthopedic surgeon to attempt to shorten the convalescent period of the patients in whom fusion is done. I think this can be accomplished by the use of internal fixation in the shape of a plate bolted to the spinous process, combined with the bone graft. Fixation of the articular process by screws is another method of accomplishing the same thing, but gives less solid fixation than the plate. When we use internal fixation it is possible to get the patients out two weeks later with the support of a brace.

I wish to congratulate the speaker on his very careful study of his cases, one of the most careful that has yet been made. I think his method of comparing his results with the preoperative condition is a real contribution, and the facts he has brought out are very satisfying so far as the results of treatment are concerned.

DR. WILDER PENFIELD, Montreal, Quebec: This is a field that has become important within a short time. In 1939, when the International Neurologic Congress was held in Copenhagen, it was proposed that a paper be given on ruptured intervertebral disk, and the statement was made that there was no such thing. Doctor Mixter, as was proper because of his pioneer work, described protrusion of the intervertebral disk for the first time then on the continent of Europe.

A great many men are operating upon these cases without serious study, and I am sure the incidence of success cannot be so high as that of Doctor Grant. We feel that all cases should be studied by pantopaque. We find that very frequently the sciatica is cured, but not the back pain. The patient whose sciatica is not cured should be studied further, and reconsidered. Many people have more than one disk protrusion, and how it is possible to make a diagnosis without complete study, simply on reference of pain, I am at a loss to know. There is the unsettled question as to when fusion should be combined with removal or used as a sequel. The question of whether the facets should be curetted at the time of removal of the disk has yet to be decided.

I think that patients in whom we are not successful should be brought back for further study and myelography—they can be cured.

DR. MAX PEET, Ann Arbor, Mich.: We believe that all patients with a possible herniated disk should be carefully studied from the orthopedic standpoint as well as from the neurologic one. There is certainly no excuse for a hasty diagnosis. I agree with Doctor Grant in much that he has said, but do differ on one particular point. We have discontinued using pantopaque in the majority of cases. Very rarely do we now perform myelography; only in those cases that are questionable have we thought it was indicated. For example, if a differential diagnosis between a cauda equina tumor and a herniated disk seems necessary, pantopaque, of course, should be used. We also perform myelography in patients with a rather clear-cut history of a herniated disk, but with negative findings on neurologic and orthopedic examinations. We have two reasons for the elimination of myelography in the majority of patients: First, in the typical case a definite diagnosis can be made on history and physical findings; second, we have found that there is a factor of error in myelography. We have had patients with perfectly definite evidence of a disk on myelography, and at operation no herniation or protrusion was found and, conversely, we have seen negative myelograms and at operation have found a large herniated disk.

We have been impressed with the modification of the usual symptom complex shown by a number of patients. These gave a history of the usual primary backache, followed some time later by sciatic radiation of pain with a subsequent disappearance of the low backache, but a persistence and, in many cases, a marked increase in the pain radiating down the leg. I had not thought of the significance of this until Doctor Badgley of our Orthopedic Department pointed out to me that every one of these cases had had a complete protrusion of the herniated nucleus pulposus, which was found to lie free under the dura. I think this may be the explanation. The loosened disk had completely herniated and lay loose, either above or below the disk space, thus, relieving pressure on the nerve endings in the posterior annulus fibrosus and posterior longitudinal ligament. It seems a reasonable assumption that it is pressure upon these particular nerve endings which gives backache when a disk is protruded. Recently, in a patient showing this modification of the symptom complex, I found the disk space clear, but the completely ruptured nucleus pulposus had slipped down into the upper sacral canal and was wedged against a sacral nerve. Had there not been a few strands of the nucleus protruding from beneath the dura, I might have missed it.

We believe spinal fusion is indicated in comparatively few patients with herniated nucleus pulposus. At times we have recommended fusion when great mobility of the vertebrae was found at the time of operation. We have also recommended it in patients who had persistence of backache although the leg pain had been removed by excision of the disk. We are opposed to fusion operations in cases of suspected herniated disk, since we have had to operate upon some cases for a persistent pain due to a ruptured disk with protrusion of the nucleus when a successful fusion had already been accomplished. This makes the operation considerably more difficult.

DR. FRANCIS C. GRANT, Philadelphia, Pa. (closing): I am very much obliged to the various gentlemen who have taken the time to give this subject their consideration, particularly Doctor Bennett and Doctor Wilson. There is one group of cases that one meets in handling patients with a ruptured disk that we have not had time to cover in any detail. Those are the cases in which the disk injury is produced while the patient is at work and where the question of compensation plays a part in the general situation. When compensation is a factor it is unquestionably more difficult to obtain a satisfactory result than in those cases in which compensation is not a major consideration.

Doctor Mixer has spoken of the occasional emergency case in which there has been rather abrupt interference with bladder function. Under these circumstances, of course, an immediate laminectomy is indicated. However, the cases who have obviously a disk, and in whom a foot drop occurs, are not, in my opinion, necessarily in

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need of immediate surgical intervention. I have seen three of these cases who developed a complete foot drop, and the foot drop finally recovered spontaneously without operative intervention.

I agree with Doctor Wilson and Doctor Peet about myelography. We carry it out in the great majority of our cases because it tells us something of the size of the disk. As was noted in the first group of cases, it was our experience that the larger the disk the better the ultimate result. This information can be obtained from myelography. Pantopaque should always be used because it can be removed later. We find, on the whole, that the clinical symptoms are a better guide to the necessities of the case than are the myelographic findings. However, in a patient who has relatively few symptoms and a negative myelogram, no surgical intervention, of course, would be indicated. I feel that myelography is useful and, after one has had experience with it, of considerable value.

## PENETRATING WOUNDS OF THE CHEST IN THE PACIFIC AREA\*

### AN ANALYSIS OF 180 CASES

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THE PRIMARY OBJECT of this study was a critical review of the care of a group of wounds of the chest from their inception to final disposition. The follow-up phase of this study was at times difficult, and was made possible only through the fine coöperation of the U. S. Marine Corps, the Navy Department, the Veterans Bureau, and personal communiques from the wounded.

The care of penetrating wounds of the chest sustained in the Pacific Theater was of necessity modified from time to time due to the changing conditions in that area. The island-hopping operations, the character of the terrain, and the great distances between advanced bases prevented segregating the early casualties into specialty groups and despatching them to designated hospitals.

To offset early difficulties in the care of patients, specialty teams were formed by the army and navy, their purpose being to serve in the combat zone, augmenting and guiding the existing medical personnel during the more active phases of fighting. It soon became apparent, however, that in injuries to the chest little definitive care of major importance could be provided in the forward dressing station or even in the field hospital without adequate roentgenographic studies, without closed endotracheal anesthesia, and without special equipment so necessary in doing definitive work on this group of patients.

It, therefore, became expedient to train the doctors and the corpsmen in the forward combat zones in the immediate or emergency care of the chest wounds.

The following specific emergency measures were stressed:

(1) The initial care of the sucking wound by the application of a large sterile gauze or vaselined dressing and firm strapping.

(2) The recognition and care of a tension pneumothorax by the insertion of a short-beveled No. 15 needle, with finger cot attached, in the second or third interspace two fingers' breadth to the left or right of the sternum, supplemented by the substitution of an intercostal catheter if the needle did not suffice. In this series a tension pneumothorax was encountered in three cases. A catheter was resorted to in one instance. It was removed on the fifth day without incident.

(3) The detection of rib-cage instability and the simple means of affording relief (a) by having the patient placed on the affected side; (b) by strapping the affected side; (c) by the injection of the intercostal nerves; and (d), when

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necessary, providing some means of external support. In our series this condition as a distressing factor presented itself only on two occasions and was adequately handled by firm strapping and by placing the patient on his affected side.

(4) The gravity of a progressive mediastinal emphysema was discussed and a suprasternal incision with tube drainage advocated. Only one case in this series required surgical relief. A tracheotomy tube was introduced into the soft tissues of the suprasternal notch paralleling the trachea. After a few days the wound in the trachea sealed-off, and the tube was removed from the soft tissues without incident.

(5) Small repeated aspirations without air replacement were recommended for progressive hemothorax when respiratory difficulty became alarming. Except when progressive bleeding was definitely coming from the chest wall, this procedure together with the various supportive measures sufficed to permit stabilization.

In addition, a few general measures were stressed as part of the patient's emergency care: (1) Morphine in moderation. (2) Maintaining a clear airway. (3) Administration of intranasal oxygen. (4) Administration of whole blood, plasma, or serum albumen, the amount and rapidity of administration being dependent on the degree of moisture in the lungs, and on the absence of increased venous pressure. (5) The use of an intranasal gastric tube if a thoraco-abdominal injury was suspected. (6) The optimum position of the patient was determined by the presence of severe hemoptysis, degree of shock, and stability of the affected rib-cage. Some patients were more comfortable with head and chest slightly elevated, and usually respirations were less labored with the patient on his back and inclined toward the affected side.

Certain interesting facts were recorded in their histories. In the earlier campaigns, where most of the fighting was in the jungle, a relatively high number were struck by sniper bullets when lying prone or in a kneeling position. Later, many were injured while standing erect. In the final analysis, 68 were standing when struck, 45 kneeling, and 44 lying prone.

Only 31 stated they were unconscious, and 13 used the term "dazed." One hundred and twenty-six stated they did not lose consciousness. In those who survived, severe hemoptysis was a very rare complication. A small amount of blood was raised by 97. The remaining 73 raised no blood at any time. The frequency and severity of pain, cough, and dyspnea varied considerably, as would be expected. For the most part, these patients stabilized in a forward station or aboard ship in the first few days. Chemotherapy was administered almost routinely, in the early campaigns in the form of one of the sulfa drugs, later augmented by penicillin. Elective aspiration or elective surgery was usually carried out at a secure rear base hospital.

Of the 180 cases, ten died. Eight deaths were immediate or within a few days, and two late deaths occurred after return to the U. S. A.



## BRIEF CASE SUMMARY OF DEATHS

Case 1.—Portal of entry wound only. Missile—shell fragment. The missile penetrated the left lower chest imbedding itself in the diaphragm in such a way that one sharp spicule penetrated the pericardium, making contact with the tip of the left ventricle, with resultant hemopericardium, tamponade, and subsequent signs of right heart failure. This patient survived four days following injury.

Case 2.—Through-and-through, thoraco-abdominal sucking wound. Missile—bullet. This patient bled severely from his wound. On date of injury local packing of the wound was not sufficient to control bleeding. Later the same day open thoracotomy was performed and lower left pleural cavity packed. Four days following injury the stomach was found to be in the chest, and on the fifth day the patient was reoperated on board ship. The spleen which was lacerated was in the chest and was removed, the stomach replaced, and the diaphragm repaired. The patient developed generalized abdominal distention on the fourth postoperative day and died on the sixth as a result of generalized peritonitis and left pyopneumothorax. Infection had spread through a small defect in the diaphragm.

Case 3.—A through-and-through thoracic wound. Missile—bullet. The bullet traversed the right auricle in its line of flight. Patient was dead within 15 minutes as a result of rapid exsanguination into pericardium and right pleural cavity.

Case 4.—Portal of entry wound only. Thoracic. Missile—shell fragment. Died within a few minutes of injury. Autopsy revealed a through-and-through wound of the left ventricle with an hemopericardium under pressure. Death from severe hemorrhage with cardiac tamponade.

Case 5.—Portal of entry wound only. Thoracic. Missile—bullet. Patient lived seven hours. Bullet entered right chest shattering the second rib. Some rib fragments were found in the lacerated lung tissue at the postmortem examination. Patient went into immediate shock, with blood pressure 84/46. Pulse 128. Respirations 30. Air was aspirated from right chest, but continuous drainage was not afforded. He developed an emphysema from the face to the scrotum. Autopsy finding revealed a lacerated upper lobe with division of bronchus three millimeters in diameter. Right pleural cavity contained air and approximately 1,000 cc. bloody fluid. Death was the result of hemorrhage and tension pneumothorax.

Case 6.—Portal of entry wound only. Thoracic, sucking wound. Missile—bullet. Patient lived approximately 15 hours. He was in shock on entry to the hospital, blood pressure 84/60. There was no hemoptysis. Wound of right thorax was dressed. After few hours 450 cc. dark blood and 600 cc. air were aspirated from right chest. Oxygen was administered, but patient died. At autopsy, second, third, and fourth ribs were found to be fractured. There was a large laceration of right upper lobe. The bullet was found in the left upper lobe. There was approximately 1,500 cc. blood in the right thorax. Abdomen negative. Death from exsanguination.

Case 7.—Through-and-through wound of right chest. Thoraco-abdominal, with two sucking wounds. Missile—bullet. The sucking wounds were closed. Oxygen administered. Twenty-four hours later patient became worse. The heart seemed displaced to the left. Six hundred cubic centimeters of sanguineous fluid removed from the right pleural cavity. Patient given 1,000 cc. of blood and 1,000 cc. of plasma. Bleeding thought to be from an intercostal vessel. An excircling suture was placed in endeavor to stop it. Shortly thereafter he vomited an enormous amount of fluid and died. Autopsy findings revealed a large ragged hole in the right diaphragm through which some lacerated liver tissue protruded. The right lung was collapsed by 1,500 cc. of bloody fluid in right pleural cavity. There had been bleeding from fractured ribs, intercostal vessels, lacerated diaphragm, and liver. The acute dilatation of the stomach probably played a rôle in his death.

Case 8.—Portal of entry wound only. Thoraco-abdominal. Missile—bullet. The bullet entered the left chest in the anterior axillary line opposite the fourth rib. Abdomen was tender and rigid in all quadrants. The direction of wound indicated probable intra-abdominal injury. In spite of 1,500 cc. of plasma and 500 cc. of blood, patient died within

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two hours after entry. At autopsy, fecal material escaped from the wound of entry. There were fractures of the seventh, eighth, and ninth ribs laterally, a small laceration of the left lower lobe, a large rent in the diaphragm, a large hole in the stomach, two large holes in the transverse colon and a small perforation of the jejunum. There was 2,000 cc. of blood in the abdominal cavity and approximately the same in the left thoracic cavity. Death from exsanguination.

Case 9.—Multiple portals of entry. Wounds along left thorax and left flank, which were considered as thoraco-abdominal. Missile—hand grenade fragments. The chest was treated conservatively. An emergency celiotomy was performed on the day of injury. The spleen was removed because of a through-and-through laceration. A large retroperitoneal hematoma was noted, but the kidney contour appeared normal. During convalescence overseas, a pyuria was present, and some deformity of the left kidney pelvis was noted. He was returned afebrile and ambulatory to the U.S.A. A few days after arrival at a West Coast hospital he died from a sudden hemorrhage from the injured left kidney.

Case 10.—A through-and-through wound. Thoracic. Missile—bullet. The wound involved the left chest and left shoulder girdle. The injury was not remarkably different from many others. He received some initial whole blood and plasma, but no excessive amount was required. The chest was aspirated on the third day because of difficult breathing, and two or three times during the subsequent two to four weeks. He was returned ambulatory and afebrile to the U.S.A. Eleven weeks following his injury, while convalescing, he suddenly developed a fulminating acute hepatitis and died in four days. All supportive measures were of no avail. Autopsy revealed only acute hepatitis.

In retrospect, it is fair to state that of the eight early deaths Cases 1, 2, 5, and 7 might have survived if it had been possible to examine more carefully and to evaluate properly all existing conditions. The two late deaths were unpredictable and unavoidable.

Of the 170 survival group, 134 were considered as thoracic wounds, 36 as thoraco-abdominal wounds, and 22 as sucking wounds. Eighty-eight were through-and-through wounds and 82 had portal of entry wounds only. The causative agent was as follows: bullet 96 cases; bomb, mortar, or shell fragment 60 cases; grenade fragments 12 cases, and bayonet two cases.

In the Pacific Theater, under the existing conditions, early aspiration was recommended only as an emergency measure for relief of respiratory distress and was done without air replacement. In this series it was resorted to in 17 cases in the first 72 hours. Elective aspiration, for the most part, was done aboard a well-organized hospital ship or at a secure rear base hospital. In 80 cases elective aspirations were performed during their convalescence, and in 87 no aspirations were performed.

In this series we have classified 36 as having thoraco-abdominal wounds. Eighteen were considered through-and-through wounds and 18 portal of entry wounds only. Nine major emergency operations were performed, six consisting of exploratory celiotomies and three of major explorations of the wounds of entry. There were 18 elective operations in this group. Ten were performed overseas and eight after returning to the U. S. A. The complications encountered were: empyemas, seven; kidney laceration or contusion, six; diaphragmatic hernia, three; subdiaphragmatic abscess, two; subdiaphragmatic bleeding (severe), one; and intercostal neuralgia (severe), three. The final disposition

of this group was as follows: To duty overseas, four. Returned to the U. S. A., 32. In the U. S. A. 13 returned to a duty status, and 12 received medical surveys because of thoracic lesion; and seven received medical surveys primarily because of nonthoracic disabilities.

Empyema developed in 20 cases. Twelve were considered thoracic wounds, seven thoraco-abdominal wounds, and seven of the 20 had sucking wounds. Bronchial fistulae were demonstrated in five of these cases. Ten cases were through-and-through wounds, and ten were portal of entry wounds only. The bullet was the causative agent in ten, mortar shell fragment in six, and grenade fragment in four. Foreign bodies were removed from the pleura in four, and from the liver in two. One empyema developed following repair of a diaphragmatic hernia and one empyema developed following a pneumonia on the good side, the penetrating wound and hemothorax being on the opposite side. All received chemotherapy in one form or another. Three were treated and successfully converted from positive to negative culture by repeated aspirations and penicillin administered intrapleurally and intramuscularly. Retarded expansion was noted in all three, one requiring a subsequent thoracoplasty. In three, initial intercostal drainage was performed followed later by rib resection. In 12, a small rib resection was done using a tube with finger cot attachment for drainage, thus, providing a semiclosed type of system which permitted early ambulation. In four, an Eloesser skin-to-pleura flap drainage was instituted. Three of these had bronchial fistulae. One drained adequately from the lower border of his operative wound. All 20 were returned to the U. S. A. for further convalescence. Two required additional local drainage in the U. S. A. Two had minor plastic procedures on resultant scars. Three required serial thoracoplasties to obliterate residual space. Two of these had large bronchial fistulae. The third was one of the cases treated by repeated aspiration, with conversion but retarded expansion. Of this group of 20, 15 received a medical survey, 13 because of the chest lesion and two for nonthoracic lesions. Five returned to a limited or full duty status.

*The Removal of Foreign Body:* Of the 82 cases having portal of entry wounds only, two had their foreign bodies removed during an emergency procedure, as the foreign body lay in the proximity of the operative wound. In 23, foreign bodies were removed as elective procedures overseas and three in the U. S. A. One patient passed his bullet per rectum. The foreign body was removed from the chest wall in 11, from the pleural space in six, from the lung in four, from the mediastinum in two, and from the liver in two.

The remaining 84 cases who were returned to the U. S. A. had very little surgery after their return. One bullet was removed from the pleura, one received a thoracoplasty for incomplete expansion, two received a semiclosed type of drainage for encapsulated residual hemothoraces, and two had intercostal nerves explored for persistent intercostal neuralgia. No pulmonary suppurations were encountered in any of this group. No late pleural supuration was noted to occur in any of this group after return to the U. S. A. Two of the cardiac complications were of interest. One case developed an

## PENETRATING WOUNDS OF CHEST

extensive pericardial effusion two or three weeks after injury. It gradually receded without aspiration. The patient is clinically quite well and working. The second case developed an adhesive pericarditis within three weeks of injury. This case had a large metallic fragment in the interventricular septum. At operation for its removal, it was thought best to leave it alone because of the depth in which it lay in the interventricular septum and also for fear of additionally injuring an already thinned and weakened postventricular wall. The patient has been perfectly well and working for over a year. He has no symptoms referable to his foreign body.

In considering their disposition one might add that over 150 of the survival group were Marines. This factor of course accounted for the relatively high number receiving medical surveys in the U. S. A. The Marine Corps would often recommend a medical survey rather than having the patient return to a limited duty status. Of the 170 survival group, 112 were returned to limited or full duty. Of this number, 34 returned to duty overseas. Of the 78 returned to duty in the U. S. A. seven later reentered a hospital and were later surveyed. Twenty-four received medical surveys for nonthoracic disability, the chest condition having cleared. Forty-one were surveyed mainly because of their thoracic injury. Of this latter group, 28 are now receiving pension; nine, rating a 100 per cent disability; one, 80 per cent; one, 60 per cent, six, 50 per cent; and 11, less than 50 per cent.

An analysis of the 41 cases relative to their working ability at the moment reveals that three are attending school as provided for in the G.I. bill of rights; 23 are known to be employed; nine state they do not feel able to work at this time; and six did not reveal their working status.

### SUMMARY

In summary, one may say that the thoracic wounds as a whole adapted themselves rather well to conditions as they existed in the Pacific Theater. In this series approximately 21 per cent were considered as thoraco-abdominal wounds, and 12 per cent developed empyemas. Four cases, or two per cent, required thoracoplasty. A properly-timed open thoracotomy, with decortication, may well have modified or prevented the necessity of these collapsing procedures. Approximately 20 per cent are receiving some pension at this time. All but five per cent have apparently adjusted themselves very well. This would seem to be a rather gratifying figure when one considers the character of injuries sustained.

DISCUSSION.—DR. WILLIAM L. ROGERS, San Francisco, Cal. (closing): I am sorry time would not permit reviewing and discussing the roentgenograms of some of our difficult therapeutic problems and to show their recent follow-up films. We are indebted to Captain Hook, who made it possible for us to see and care for many of these cases while under his command in the South Pacific.



## FRACTURES OF THE OS CALCIS\*

THEIR TREATMENT BY TRI-RADIATE TRACTION AND SUBASTRAGALAR FUSION

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THE MANAGEMENT OF FRACTURES of the os calcis is difficult. There are three reasons for this:

1. Standardization of treatment is nearly impossible because the damage sustained by the os calcis varies within such great limits as to present widely different problems in management. Few fractures are as individualized as are fractures of the os calcis. They range from the most insignificant fissure (Fig. 1) to the most extreme degree of comminution with gross deformity (Fig. 2).
2. The technical problems involved in reduction of the fragments are complex and difficult to solve.
3. Involvement of the subastragalar joint frequently occurs. When it does, late disability from pain on movement is almost inevitable, even though good reduction of the fracture has been obtained.

In so difficult and complex a problem, it is not surprising that much difference of opinion exists regarding the best form of treatment, nor is it surprising that the results often are unsatisfactory.

In civil life most fractures of the os calcis are the result of industrial accidents: Falls from scaffolds, falls from buildings, falls from ladders are the frequent causes of the injury. The records of the Workmen's Compensation Boards bear testimony to the serious disability which is caused by this accident. Dr. D. E. Bell,<sup>1</sup> Chief Medical Officer of the Workmen's Compensation Board of Ontario, has been kind enough to provide me with data relating to 60 consecutive cases of fracture of the os calcis. Simple fractures and much comminuted fractures are included in this group without distinction. The duration of total disability (in almost every case this corresponded to the period from the time of the accident to the time the man returned to work) varied from two and one-half months to 35 months (Fig. 3). The majority of the cases (all save nine) were back at work at the end of 14 months. Most were left with some partial permanent disability necessitating compensation. Thirty-five were placed on pensions varying from 3 per cent to 50 per cent. The remainder received compensation for temporary partial disability at rates ranging from 3 per cent to 35 per cent and for periods ranging from six to 42 months. Not one case reached a finality with no disability at all. Ten cases had subastragalar and midtarsal fusions after rather prolonged periods of disability had demonstrated their inability to work. The average cost was great; \$1,350.00 per patient.

\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.



## FRACTURES OF THE OS CALCIS

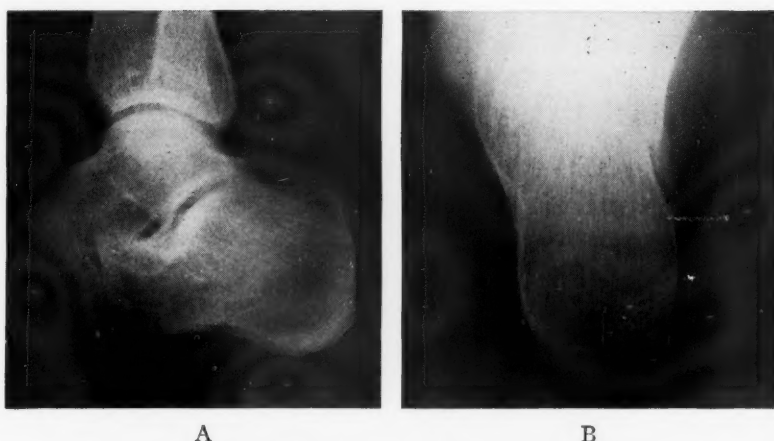


FIG. 1.—A fracture of the os calcis with minimal damage to the bone and minimal displacement of the fragments. (A) Lateral view; (B) supero-inferior view. (For contrast with Figure 2.)

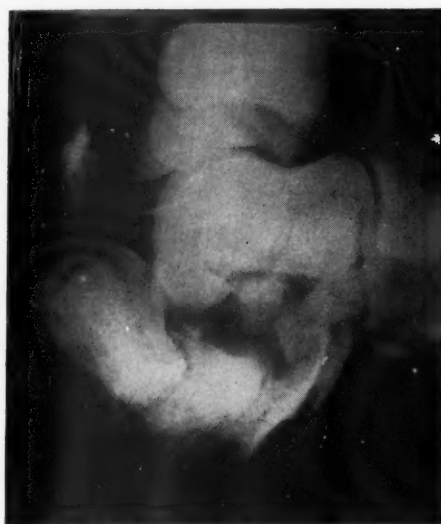


FIG. 2.—War fracture of the os calcis, the result of the explosion of a land mine beneath the vehicle on which this soldier was riding. This represents the most extreme degree of fragmentation and deformity which can occur in fractures of the os calcis. Every gradation in severity can occur between that represented in Figure 1, and that represented here.

War now adds its toll to this group of fractures. In the war which has just terminated, severe fractures of the os calcis were amongst the most characteristic of injuries. In civil life the injury is caused by a fall from a height. In war it most characteristically results from force exerted from below. Land mines exploding under vehicles and under tanks drive the floor up against the feet of the occupants with great force. Similarly, when ships are torpedoed or mined, the explosion lifts the deck suddenly and violently. This force is sufficient to cause fractures not only of the os calcis, but often, also, compression fractures of the spine. A war variation of the fractures of the os calcis, which is due to a fall from a height, were those

produced when sinking ships developed a list so great that the crew slid across the deck and came up against the bulwark or other object. If their heels bore the brunt of the impact, fractures of the os calcis occurred.

War fractures of the os calcis are characterized by an extreme degree of comminution of bone which often is shattered into multiple widely separated fragments (Fig. 2). The injury often is compound. There may be serious injury to the circulation from swelling and vascular damage. For these reasons and also because of transportation problems, there was little opportunity for the early institu-

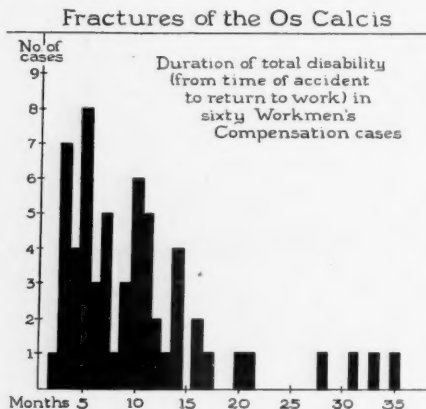


FIG. 3.—Graph of duration of disability in fractures of the os calcis. Workmen's Compensation cases.

tion of specialized treatment directed towards the reduction of the fragments. Most war fractures of the os calcis have ended with fusion of the fragments into a greatly distorted mass. It must be stated, however, that the degree of permanent disablement, though severe, often is not as great as might be expected from the distortion of the bone.

#### BOHLER'S CONTRIBUTION TO TREATMENT

An important landmark in the problem of os calcis fractures has been Böhler's contribution to their treatment. His emphasis upon the multiplicity of fracture types, each of which requires its own treatment, upon the need for the restoration of the bone to its normal shape and the value of traction in securing this, have greatly advanced the standards of our treatment. Perhaps of even greater importance than his contributions to the technic of treatment has been the enormous stimulus he has given to our interest in this grave problem. Nonetheless, the fracture too often is poorly managed.

Many fractures of the os calcis are treated by simple plaster fixation without any attempt at reduction or of restoration of the bone to its normal contour. Commonly, this results from the inexperience of the practitioner

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and his inability to handle a complex problem. He puts on a plaster encasement and hopes for the best. But there has also grown up a school of fracture surgeons who advocate "studied neglect" as the best form of treatment. This surely must be a confession of defeat. It is impossible to believe that a badly comminuted fracture of the os calcis with serious involvement of the subastragalar joint will be better if left untreated than if reduced. Even Cotton's method is based upon the principle of reduction of the fragments and restoration of the normal contour of the bone. The initial pounding is for the purpose of disimpacting the fragments so that they may more easily be remoulded into normal relationship.



FIG. 4.—Fracture of the os calcis with a central fragment bearing articular cartilage completely separated by fracture lines from the surrounding bone. This results in aseptic necrosis, loss of articular cartilage and damage to the subastragalar joint no matter how perfectly the fragment may be reduced. (See Fig. 13.)

Success in the treatment of this, as of other fractures, is based upon reduction of the fragments to as nearly perfectly normal relationship as possible.

Böhler's plan of treatment, though valuable and important, falls short of perfection on several points. First, and most important, is the assumption that a rigidly formalized procedure will always result in a satisfactory reduction of every fracture of the os calcis. There is so much variation in os calcis fractures, in the amount of comminution and in the degree of displacement, that perfect reduction cannot always be expected from a pro-

cedure which consists of traction in a certain direction with such and such a force followed by traction of a certain amount in another direction. The second defect follows from the first. There is no provision for determining, *during* the period of reduction, whether success has been achieved or not. The stress is upon maintaining a certain degree of traction in a certain direction, the inference being that strict adherence to this formula will be cer-

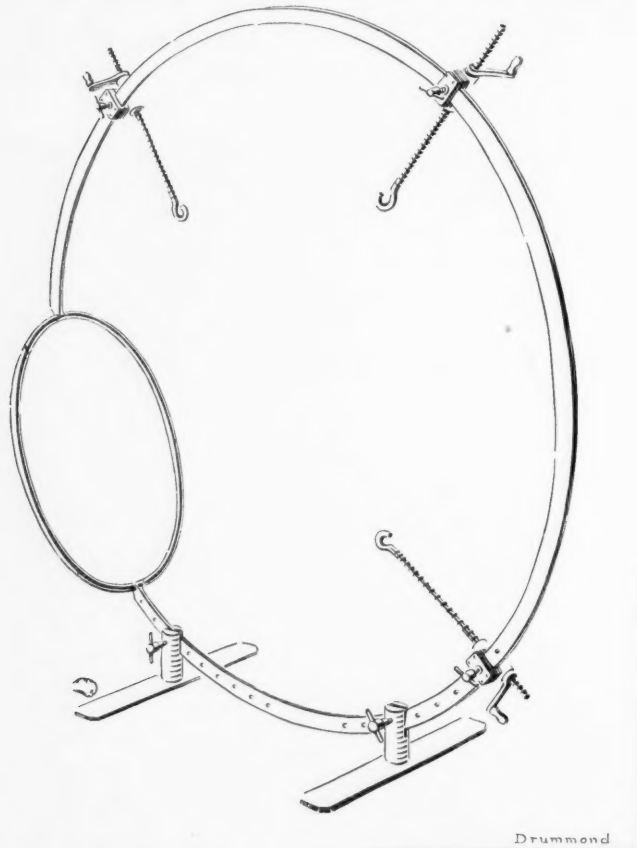


FIG. 5.—Sketch of the traction ring by means of which tri-radiate traction is used to reduce the fragments of the fractures of the os calcis. The leg is passed through the oval opening. Kirschner wire traction is then applied from three points—shin, heel and toes. The direction of the pull of each traction unit may be altered within wide limits by shifting its anchor-block around the ring. The traction force may be modified by the screw tension.

tain to produce the desired reduction of the fracture. Like most fractures, the success of treatment should be checked by roentgenograms or the fluoroscope. Undue stress, also, is laid on restoration of the critical angle. This is an index that fair restoration of the fragments to their normal relationship has been obtained. Of greater importance is the state of the posterior facet of the subastragalar joint. If this is intact it matters not whether the critical

angle is restored exactly. Good results will follow even when the critical angle is much depressed provided the subastragalar joint is intact. On the other hand, if the joint has been involved in the fracture, the final result is prone to be imperfect no matter how well the critical angle has been restored or how perfect the reduction of the fragments.

Böhler's method of reduction by traction would be improved were there provision for at least one additional point of traction and for greater flexibility in the directions in which the traction can be applied. But even when this improvement has been attained, it is a mistake to assume that the distortion of the bone can be corrected by traction alone. Certain fractures of the os calcis cannot be completely or satisfactorily reduced by traction alone, no matter how skillfully its direction and force may be manipulated. Other means of controlling the position of the fragments often are necessary.

Bohler fails also to lay sufficient stress upon the value of subastragalar fusion in the more serious cases. Disablement from a damaged subastragalar joint is so certain to follow certain types of injury that they should be recognized at the outset and treated by early fusion.

#### PRINCIPLES OF TREATMENT OF OS CALCIS FRACTURES

This paper records an attempt to improve upon the treatment of os calcis fractures and relates the results obtained in 35 cases. During the course of this study certain principles of importance have evolved. They form the basis of any rational attempt to improve this treatment of os calcis fractures and are worthy of emphasis.

1. The fundamental principle of treatment is that best results will be obtained by reduction of the fragments to their normal relationship to each other. The more nearly this can be accomplished the better will be the result. Though perfect reduction may not necessarily ensure normal function, it will give the best result obtainable. To leave the fracture unreduced may have the merit of simplicity but it results in too much permanent disablement. "Studied neglect" has no more to recommend it in the treatment of fractures of the os calcis than it has in other fractures.

2. It is important to distinguish between simple and severe fractures of the os calcis. Severe fractures, (*i.e.*, those with much comminution and much displacement) must further be divided into (a) those in which no fracture line traverses the articular surface of the posterior facet of the subastragalar joint, even though the joint be depressed; and (b) those in which the articular surface is fragmented and distorted.

The simple fractures do not present any great difficulty in treatment. If only a simple fissure exists elaborate means to change the position of the fragments are not necessary. Any widening beneath the malleoli may be corrected by lateral compression. When this has been accomplished simple fixation in a plaster encasement is all that is necessary.

If the fracture is severe some or all of the procedures outlined below may be necessary to secure a satisfactory result.



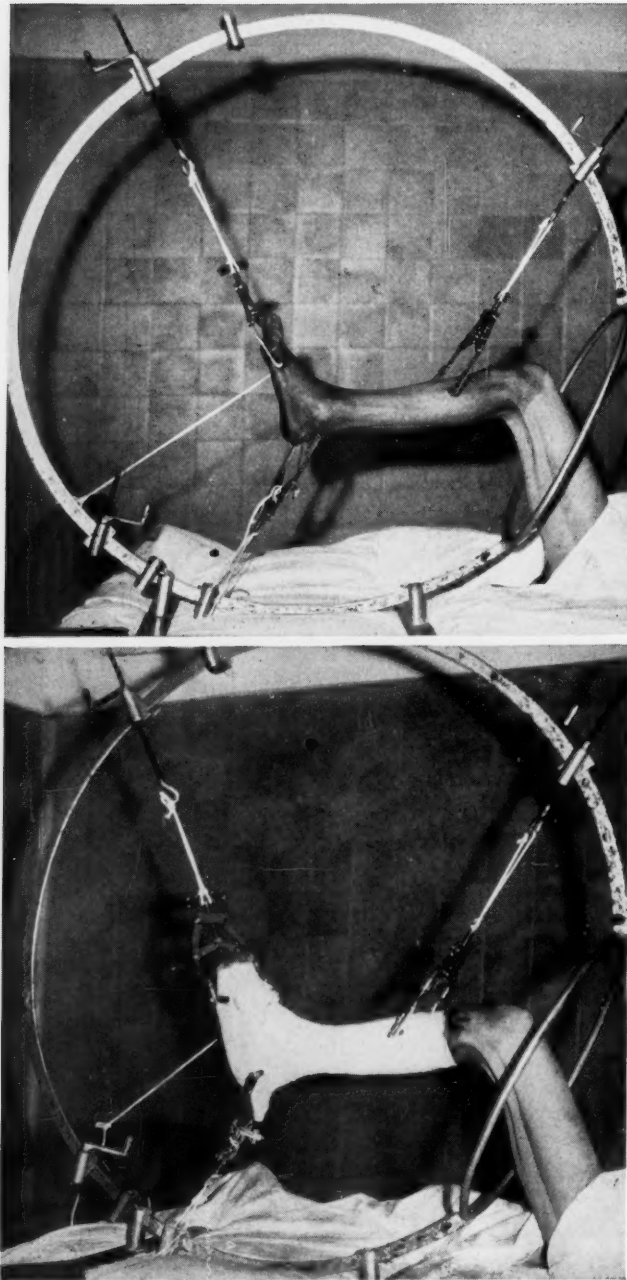


FIG. 6.—The traction ring in use. (A) The fracture has been reduced by tri-radiate traction and the position of the fragments has been demonstrated satisfactory roentgenographically. Note an extra cord holds the forefoot in the midposition between varus and valgus and a Steinmann pin has been used to pry up the anterior end of a major fragment carrying part of the articular facet. (B) While traction is maintained, a plaster encasement is applied incorporating the Kirschner wires and the Steinmann pin. (See Fig. 7 for roentgenograms.)

## FRACTURES OF THE OS CALCIS

3. Skeletal traction is a valuable agent for restoration of the fragments to their normal position and normal relationship to one another. It is important, however, that it be more flexible in its application than suggested by Böhler, and multi-directional. The insertion of the tendo achillis into the os calcis modifies the direction of the force which traction exerts through the wire transfixing the posterosuperior angle of the os calcis. In order that this force may shift the fragment in the right direction and in the right

A



B



C

FIG. 7.—Roentgenograms of the patient illustrated in Figure 6. (A) Before reduction. (B) After the application of tri-radiate traction. Position improved but anterior end of a major fragment is still depressed. (C) Restoration of normal relationship by tilting up the depressed fragment with a Steinmann pin.

manner, and to the right degree, controlled means of changing the direction of this pull are necessary. Furthermore, the shortening of the heel often is not satisfactorily overcome by Böhler's traction. Measures to accomplish this by means of a third wire through the heads of the metatarsals is a valuable addition to the traction apparatus.

4. In certain cases, traction is not sufficient to correct all the deformity. Of particular difficulty and importance is the depression of the anterior end

of a major fragment carrying with it part or all of the articular surface of the posterior facet of the os calcis. Sometimes no amount of traction applied in any direction will tilt this up. It can be accomplished by other means. Of particular value is a Steinmann pin hammered into the heel and used as a handle to pry the fragments into the proper position.

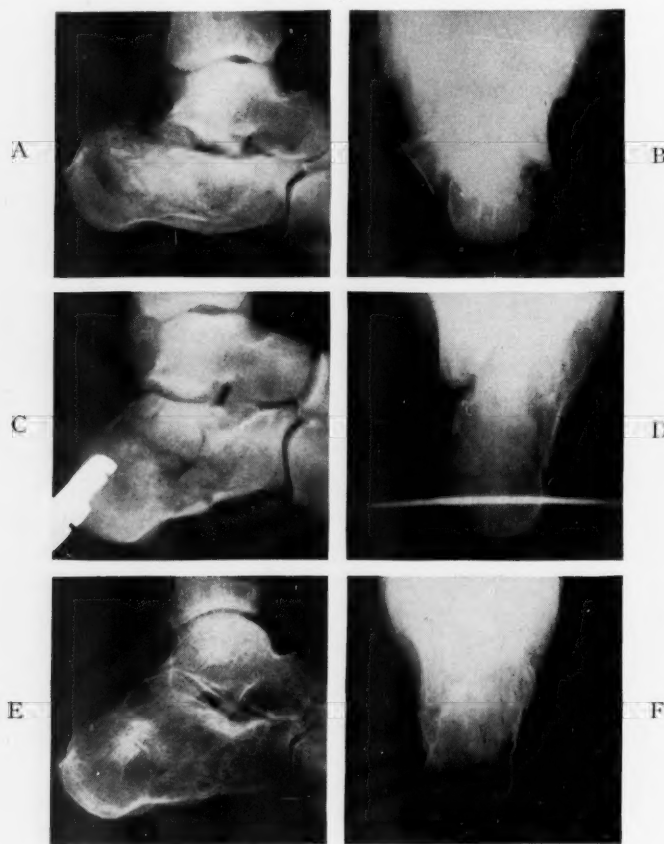


FIG. 8.—Roentgenograms to illustrate the outcome of treatment of tri-radiate traction. (A) and (B) Lateral and supero-inferior roentgenograms before reduction. (C) and (D) Lateral and supero-inferior roentgenograms taken during reduction. In (C) note a large fragment carrying most of the posterior facet of the subastragalar joint completely separated by fracture lines from surrounding bone. (E) and (F) The result three months after reduction. Good union in good position but articular cartilage thin in posterior half of subastragalar joint. (See Fig. 9.)

5. Reduction must be checked during its progress by roentgenograms or fluoroscopy, and the necessary adjustments made to achieve the perfection of reduction which is desired. This is important. It is impossible to know what has been accomplished by attempts at reduction except by roentgenograms. So often is the first attempt at reduction imperfect that check roent-

genograms at the time are the only reasonable means of obtaining good results. In this respect, fractures of the os calcis do not differ from other fractures.

6. The widening of the heel which results from the bursting force of the injury must be accurately and completely reduced. This is best accomplished by skillful moulding rather than by great compression force. When the fragments of the bone have been restored to length by traction it does not require great force to reduce the excessive width. The attempt to accomplish this by powerful compression leads to the use of instruments which make nice adjustments difficult and uncertain.

7. If there has been fragmentation of the articular surface of the posterior facet of the calcaneus, permanent disablement from painful limitation of movement of the subastragalar joint is virtually certain to occur. No means of reduction which we possess can so exactly replace the fragments that perfect restoration of the normal contour can always be attained. Therefore, involvement of the joint surface by fracture lines predicates the likelihood of late disability which can only be relieved by fusion.

8. Even though it were possible to secure perfect reduction of the fragments involving the joint surface, we must still recognize the frequent occurrence of *aseptic necrosis* of fragments cut off from their blood supply by the fracture lines (Fig. 4). In due course, they undergo changes which result in loss of articular cartilage and deterioration of the joint.

9. These two factors (fractures through the joint surface and the occurrence of *aseptic necrosis* in one or more of the fragments) lead, with certainty, to permanent disability. Such cases should be treated by subastragalar fusion to obtain the best result. They should, therefore, be recognized at the beginning and fused as early as possible in order to reduce to a minimum the time for treatment. In most cases it is not necessary to fuse the midtarsal joint.

10. The importance of accurate reduction of the fracture is so great that the accomplishment of it by open operation naturally arises as a possibility. Our experience with this procedure is not entirely satisfactory. No



FIG. 9.—The final result obtained in the case illustrated in Figure 8, two years after reduction. Loss of cartilage in the posterior facet of the subastragalar joint, sclerosis of the bone and osteo-arthritic lipping of the posterior margin of the joint. The case illustrates well the complexity of the factors involved in the achievement of a good result in the treatment of fracture of the os calcis. The fracture was much comminuted and there was much displacement. Nevertheless, excellent reposition of the fragments was accomplished. The late result was imperfect because *aseptic necrosis* of a central fragment caused loss of articular cartilage and traumatic osteo-arthritis. The joint was limited in movement and painful. Subastragalar fusion would have improved the result.

incision adequately exposes all the fragments of the fracture. Any attempt at restoration of the fragments is nearly impossible because the crushing of the cancellous center of the bone reduces a large part of the bone to mush. Fixation after reduction is difficult or impossible. Open reduction, therefore, is far from ideal. Nevertheless, two fresh fractures treated by immediate open operation and immediate subastragalar fusion are among the most satisfactory cases we have had. They returned to work in four months, with painless feet. This is a tribute to the value of early fusion rather than open operation since the deformity of the bone was poorly corrected.

#### A PLAN FOR THE TREATMENT OF THE OS CALCIS FRACTURES

The plan of treatment which this paper records consists of the following steps:

The injured foot and the roentgenograms are examined to determine whether or not the fracture is of such severity as to need reduction. The simple fissure types (Fig. 1) are treated by fixation in a plaster encasement only.

The severe types of fracture are reduced under anesthesia using a traction ring of our own design (Figs. 5, 6, 7). This device permits us to use three points of traction and to shift the direction of each within a considerable range (tri-radiate traction). The force of the traction is also capable of easy adjustment by screws.

To reduce the fracture, Kirschner wires are first passed (a) through the upper end of the crest of the tibia; (b) through the posterosuperior angle of the os calcis; and (c) through the distal ends of the fifth and first metatarsals. Care must be taken in the placing of these wires, that they be parallel to one another when the foot is in the position of reduction. The wire B., moreover, must be very exactly placed in the extreme posterosuperior corner of the os calcis in order that maximum control over the fragment may be secured.

When spreaders have been attached to the wires they are, in turn, secured to the tractors by short lengths of fine sash cord. Tri-radiate traction is then applied in the directions which seem most likely to reduce the fracture. The result is checked by roentgenograms taken in the operating room. If the reduction is not satisfactory, adjustments of the direction and tension of the traction are made and the result again checked roentgenologically. These adjustments are continued until the best possible result is secured. As a rule, this proves to be a simple procedure. The first attempt often is satisfactory.

If there is a major fragment carrying articular cartilage, the anterior end of which remains depressed in spite of every effort of traction (Fig. 7), it is elevated by the use of a Steinmann pin. This is securely driven into the fragment from behind and is then used as a handle by means of which the fragment is tilted into place. The projecting end of the pin is tied in the proper position to the Kirschner wire-spreader.



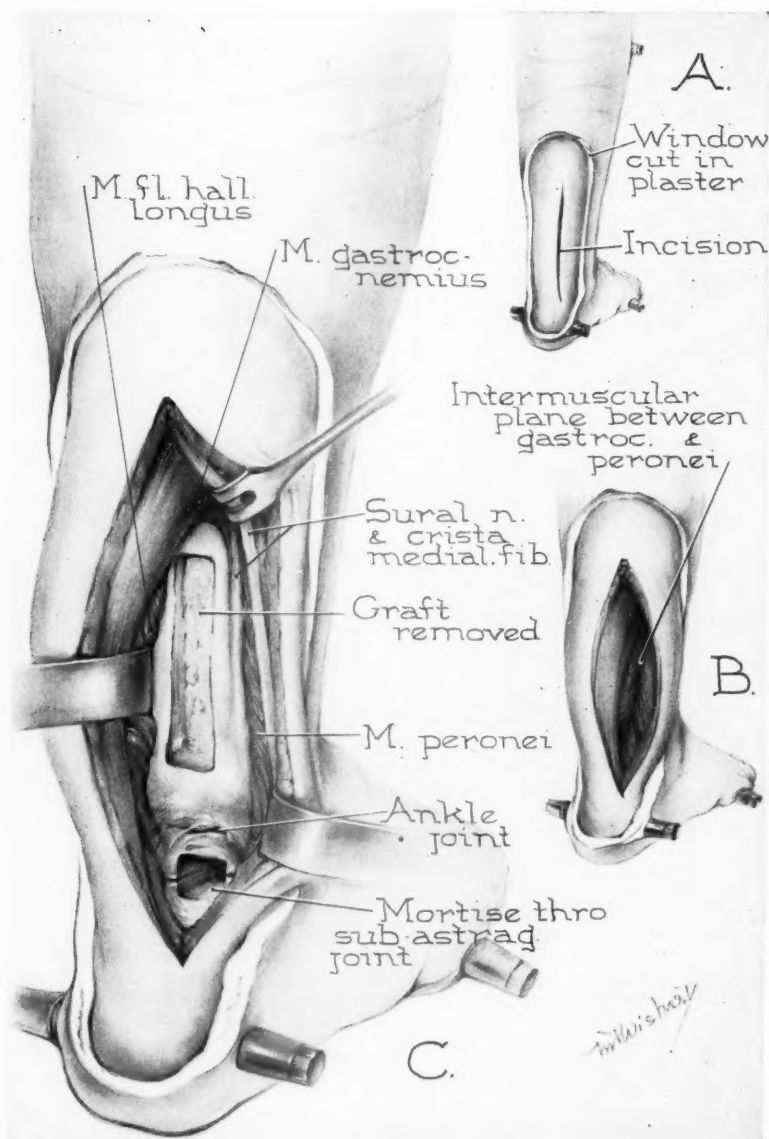


FIG. 10.—Gallie's operation (slightly modified) for fusion of the subastragalar joint through a posterior approach.

First Stages: (A) The incision lateral to the tendo achillis made through a large window in the encasement. The transfixing pins still in place and incorporated in the encasement. (B) The approach to the posterior surface of the tibia and the posterior end of the subastragalar joint by opening the intermuscular plane between gastrocnemius and peronei. (C) Flexor hallucis longus detached from its fibular origin and retracted medially with the tendo achillis. Rectangular mortise cut in subastragalar joint. Graft removed from posterior surface of tibia with osteotome.

When the lateral roentgenogram shows satisfactory restoration of the position of the fragments, the widening of the os calcis is reduced by moulding pressure from either side. This does not require great force. We prefer not to use Bohler's crushing clamp because it is needlessly powerful and is clumsy to use. Often the moulding can be accomplished by the hands alone. The final position of the fragments is determined by a supero-inferior roentgenogram (Fig. 8).

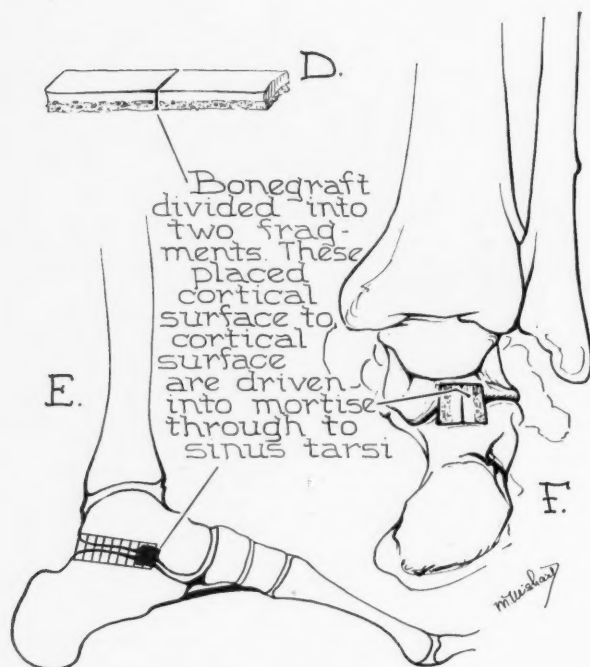


FIG. 11.—Gallie's operation for subastragalar fusion through a posterior approach.

Final Stages: (D) The bone graft is divided into two equal fragments. (E) and (F) The grafts are driven into the mortise in the subastragalar joint.

With traction still on (and the Steinmann pin still in place if it has been used) a plaster encasement is applied from toes to top of calf, incorporating the wires and pin in the encasement. The patient is then returned to the ward still suspended in the traction ring. It is removed 48 hours later, when the plaster is completely dry.

From a study of the postreduction films, a decision is reached upon the necessity, or otherwise, for subastragalar fusion. The criterion for this decision is the degree of fragmentation and deformity of the articular surface, of the posterior facet of the os calcis. If this is seriously involved, or if there are loose fragments likely to undergo aseptic necrosis, fusion will be

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necessary to secure the best result even though there has been good reduction of the fragments.

The importance of fusion of the subastragalar joint in selected cases should be emphasized. It has been our experience that many fractures of



FIG. 12.—A postmortem specimen of fracture of the os calcis. Death occurred five days after the accident.

(A) Superior oblique view of the fractured bone illustrating the great comminution of the bone and distortion of the fragments. The fragments are firmly impacted into each other and have resisted preparation of the specimen without falling apart. (1) Sustentaculum tali; (2) anterior portion of the articular facet; and (3) posterolateral portion of facet driven down into the body of the os calcis.

(B) Roentgenogram of the fracture on admission of the patient. (C) Roentgenogram of the specimen from a somewhat different angle than the clinical roentgenogram. This rare specimen illustrates well the great complexity of the fracture, the multiple fracture lines, the great displacement of the articular surface and the impaction of the fragments. It makes clear many difficulties which beset the treatment of this fracture.

the os calcis, even though well reduced, are seriously disabled by painful limitation of movement of the subastragalar joint because of involvement of the articular surface of the os calcis. When the painful joint is adequately fused the improvement is great and more than compensates for the loss of

movement in this joint. The development of a simple and effective technic for subastragalar fusion by W. E. Gallie<sup>2</sup> leads us to feel that it should be used in all cases in which there is any appreciable damage to the subastragalar joint.

If subastragalar fusion is advisable it should be performed early to avoid needless prolongation of treatment. The common procedure is to reduce the fracture, maintain fixation till union is complete, and return the man to work after a period of rehabilitation. About six months after the fracture, it begins to be apparent that he is handicapped by painful limitation of movement at the subastragalar joint. Sometime later the subastragalar joint is fused to cure his pain. This operation requires another six months of fixation



FIG. 13.—Specimen from anatomic laboratory of old unreduced fracture of the os calcis. The chief point of interest is the evidence of gross cartilage damage on a central fragment which has undergone aseptic necrosis and also the damage this has caused to the congruous articular surface of the talus.

and rehabilitation before he can resume work. Our great objection of subastragalar fusion has been the great loss of time it involves. If it is performed early this objection is eliminated. To do so necessitates deliberate selection of cases for fusion at the beginning of treatment of the fracture.

Cases which are judged suitable for subastragalar fusion are operated upon ten days after the primary reduction. The joint is fused from behind, after the method of Gallie,<sup>2</sup> through a large window cut in the plaster encasement over the tendo achillis. The transfixing wires remain incorporated in the encasement and are not disturbed. Gallie's simple procedure can be recommended as highly suitable for the problem of the fractured os calcis.

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The only important precaution is to be certain that no varus deformity exists. Fusion of the subastragalar joint in varus causes disability from uneven weight distribution on the forefoot.

The operation (Figs. 10 and 11) exposes the subastragalar joint from behind by an incision lateral to the tendo achilles. The intermuscular plane between the gastrocnemius and the peronei is entered and the fibers of the flexor hallucis longus detached from the fibula. With the tendo achilles they are retracted medially. This exposes the posterior surface of the lower end of the tibia, the posterior capsule of the ankle joint and the posterior end of the subastragalar joint. A rectangular mortise is cut in the subastragalar joint with a suitable osteotome, care being taken to ensure that it opens the astragalus and the os calcis equally. The mortise is continued forward to the sinus tarsi. A graft of suitable width is then removed from the lower end of the posterior surface of the tibia. For this purpose an osteotome must be used since the depth of the wound precludes the use of a motor saw. This modification of Gallie's original procedure is necessary because the shin is enclosed in plaster. The crest of the ilium would serve equally well. When secured, the graft is cut into two pieces and driven into the mortise. The wound is then closed, the window in the plaster filled in with a large dressing and secured with an encircling plaster.

The plaster with its transfixing traction wires remains in place eight weeks. If fusion has been performed it is replaced by a walking plaster. Otherwise, the patient begins at once to walk.

The policy of early subastragalar fusion saves months of time and permits severe cases to return to work almost as soon as the simpler cases.

### RESULTS OF TREATMENT

Since June, 1938, 35 patients with 47 os calcis fractures have been treated by this method. The results are satisfactory and are an improvement upon our previous results. Tri-radiate traction with roentgenographic control has proven a much more efficient means of securing reduction of the fragments than is Böhler's procedure. The addition of leverage with a Steinmann pin still further improves the reduction in difficult cases. Early subastragalar fusion of those cases in which there is much comminution of the posterior facet of the os calcis eliminates quickly what would otherwise be a prolonged, probably a permanent disability. The midtarsal joint does not need to be fused. Gallie's posterior approach to the subastragalar joint and his method of fusion are ideally adapted for this purpose. They permit an easy and quick exposure of the joint. The graft can be taken from the posterior surface of the tibia through the same incision. The operation can easily be performed through a window in the plaster.

With one exception all the cases were back at work within six months, some in much less time than six months. The most impressive results were obtained in those cases in whom the subastragalar joint had been fused. The contrast between the extreme degree of comminution seen in the original



roentgenograms, and the painless useful foot obtained by reduction and fusion was dramatic. One case illustrated this well since his bilateral fractures were treated, one without fusion because the fracture did not greatly disturb the joint and good reduction was obtained; the other by early fusion because

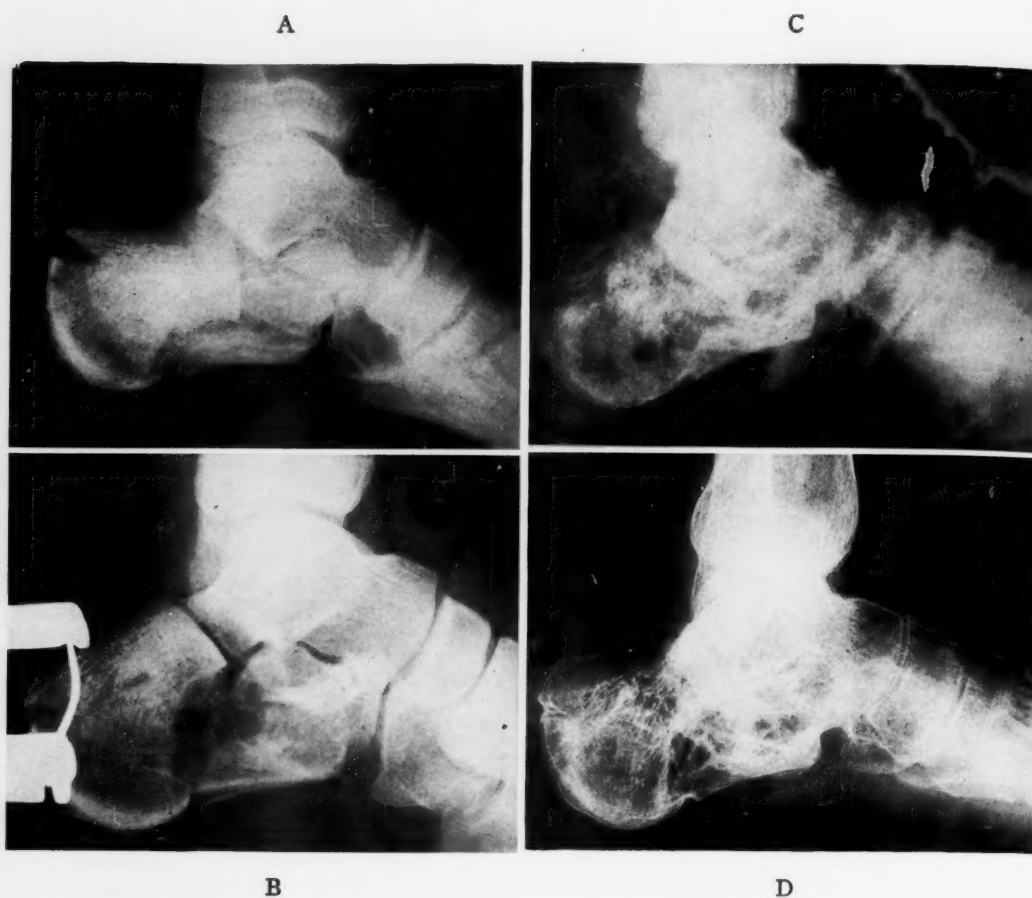


FIG. 14.—Series of roentgenograms to illustrate treatment of severe fracture of the os calcis by tri-radiate traction and early subastragalar fusion. (A) Roentgenogram before reduction. Severe fracture with much comminution, displacement and involvement of articular facet. (B) Reduction obtained by tri-radiate traction. Improvement in position but great involvement of subastragalar joint makes impaired function a certainty. (C) Early subastragalar fusion by posterior approach through a window in the plaster encasement. (D) The final result, which gave a stable and painless foot, six months after fusion.

of the extensive involvement of the joint. The foot upon which the fusion has been performed proved much the better foot, completely painless and stable.

The single exception to these good results was the result of complications which must be put on record. A low-grade but extremely persistent infection with *B. proteus* developed late (12 weeks) in the transfixion wound which carried the wire for the posterior superior corner of the os calcis.

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It cleared after many months. Later, a spur on the plantar surface of the os calcis made walking painful and had to be removed. Finally, his return to active work was prevented by a mild hemiplegia due to cerebral thrombosis. The final result has been good in spite of the hemiplegia, though it has taken many months to achieve it.

### SUMMARY

1. Fractures of the os calcis often present difficult problems in treatment and give rise to late disablement of considerable severity.
2. A plan for the improved treatment of fractures of the os calcis is outlined. Its important features are (1) an improved method of securing reduction of the fracture by means of tri-radiate traction supplemented by leverage with a Steinmann pin in certain cases; (2) the necessity of early subastragalar fusion in every case in which the posterior facet of the os calcis has been involved; and (3) Gallie's method of subastragalar fusion by a posterior approach is advocated.
3. The result obtained by such treatment on 35 patients is recorded.

### REFERENCES

- <sup>1</sup> Bell, D. E.: Personal communication.
- <sup>2</sup> Gallie, W. E.: Subastragalar Arthrodesis in Fractures of the Os Calcis. *Jour. of Bone & Joint Surg.*, **25**, 731-736, October, 1943.

DISCUSSION.—DR. KELLOGG SPEED, Chicago, Ill.: I agree with nearly every point in Doctor Harris' thoughtful paper, and might add that these fractures are the most frequently found simultaneously bilateral in the extremities. In some instances it is impossible with bi- or tri-radiate traction complemented by lateral compression to effect a satisfactory reduction after compression fracture of the calcaneus. The earlier the attempt after fracture the better the reduction may be. Application of lateral compression, when indicated by the broadening mushroom flattening of the comminuted bone, should be performed after the skeletal or extra-osseous traction on the heel is in place. When the fragments of bone are so small that a wire may not be used without additional splitting or displacement of fragments, I prefer to use pin-traction immediately posterior to the surface of the bone in front of the attachment of the tendo achillis. This can be inserted by hand through a small puncture incision and does not traverse the bone, although it may enter the hematoma about the fracture.

A postreduction roentgenogram will never tell all the success or failure of the restored position of the fragments. Inequalities must exist in every instance when the subastragalar joint is involved, but they may be healed over fibrously and aided by long freedom from weight-bearing, after which the underlying cancellous bone may eventually support body weight without pain. When there is gross inequality of the superior articular surface of the calcaneus, pain is inevitable for most individuals unless a natural bony arthrodesis develops. If the freedom from weight-bearing is persisted in only long enough to permit surface healing of the cartilage defect by fibrous tissue, the underlying cancellous bone will not have sufficient strength to support this surface when weight-bearing is attempted, and there will ensue a secondary collapse with increasing deformity of the articular surface and increasing pain. This I believe is even more important than the factors of aseptic necrosis of bone fragments and the so-called joint deterioration described by Doctor Harris. We must not conceive

the bone as having a center of cancellous bone; it is completely cancellous, with a cortex almost as thin as paper.

If Doctor Harris' ingenious traction ring is not available a variation in traction may be accomplished by using the modern fracture table, knee flexed and suspended with skeletal traction on heel and foot adequately applied to the metal foot piece. But this cannot remain there for 48 hours, thus failing to achieve the efficiency of the traction ring.

We must agree that arthrodesis is the best method of treatment for the severe fracture. After trial I believe Gallie's method is an excellent one. The posterior approach with the foot stabilized in plaster or traction permits a thorough yet dainty use of the chisel to freshen the articular surfaces, and avoids the long and disadvantageous lateral incision which may not heal cleanly or rapidly. Lateral approach, however extensive the incision, also does not permit full exposure of the superior surface of the calcaneus and cannot be used so soon after the fracture as the Gallie method. Valuable time is thus lost in the healing of the lesions as a whole, including atrophy of the leg muscles. One difficulty in the technic of the Gallie operation is in getting the fusion far enough anterior to promote firm supporting bony union.

DR. GEORGE BENNETT, Baltimore, Md.: I really did not intend to discuss this paper because I do not think there is anything left to be said. Doctor Harris covered briefly and concisely the fundamental points that must be considered in treatment of fractures of the os calcis. I am in complete agreement with his views. I think meticulous study and care of these cases with these principles carried out will eliminate a great deal of disability.

DR. R. I. HARRIS, Toronto, Ont. (closing): I should like to state that the paper is based upon the treatment of 35 patients who had 47 fractures of the os calcis. The results are satisfactory, and are an important improvement over our previous results. With one exception all were back at work in six months or less. The most impressive results were in those on whom subastragalar fusion had been done. These were the worst cases, severely comminuted and with involvement of the subastragalar joint; yet it was possible to get them back to work early (six months) with a painless foot.

## COMPOSITE FREE GRAFTS OF TWO SURFACES OF SKIN AND CARTILAGE FROM THE EAR\*

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AND

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THIS TYPE of free graft from the ear, consisting of two surfaces of skin and intervening cartilage, was reported from this Service, first in Surgery, Gynecology, and Obstetrics, March, 1946, Vol. 82, 253-255. Further observations have been made and are recorded here along with material from the original publication.

The procedure is still recognized as a difficult one whose success is dependent on a rather small margin of obtaining a satisfactory minute blood supply for a relatively small piece of grafted tissue. The usefulness of the graft is found mainly in reconstruction of the nasal tip, columella, and ala, and as most defects here have scarred edges, the problem of dissecting back to the adequate minute blood supply in this donor site must be met.

The grafts make possible the transfer of a bulk of tissue with two surfaces of skin and an upright or armature of cartilage between them, and are obtained from any part of the ear where this condition exists. The helix and the crus of the helix are used mainly, and other areas around the triangular space and some flat grafts with one surface of skin and attached cartilage are possible. These are taken from these same areas or from behind. The contained cartilage gives the desired form and stability to the graft, and, at the same time, this same cartilage apparently makes the grafting of this bulk of tissue possible by supplying an internal stretch of the skin and support while the blood supply is being established around the edges. This transplanted cartilage does persist and can be definitely felt in the graft months after transplantation.

The donor site in the ear is repaired directly with a local flap or closure, or directly with a scalp flap, the open ear being planted under the flap. This flap is let loose later and a free skin graft used on the scalp if necessary. This procedure on the ear is outlined in Figures 1 and 2. Little deformity

\*This work has been done in association with Major Carl Lischer, Major William Bowdoin Davis, Captain Andrew M. Moore, Captain Joseph Murray, Lt. Allyn McDowell, Lt. Milton Edgerton, Lt. Paul Jensen, Major Byron West, Major R. W. Shearburn, Major Parke Scarborough, Major Sidney Bloom, and other surgeons working in this Plastic Surgery Center, at Valley Forge General Hospital.

Read by Title at the American Surgical Association Meeting, April 2-4, 1946, Hot Springs, Virginia.

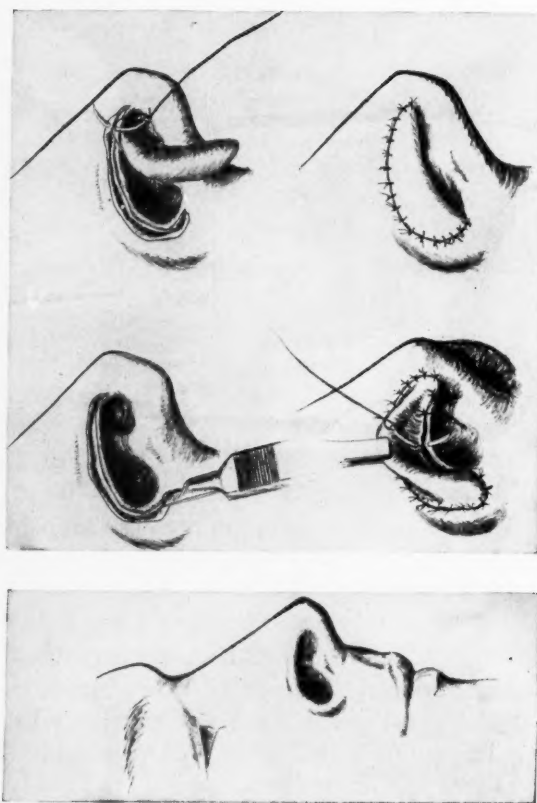


FIG. 1.—Composite free graft from ear to reconstruct nostril border. Single operation on nose.



## COMPOSITE FREE GRAFTS

results, and the patients do not complain. If the ears are burned, or otherwise destroyed, the source of graft is lost, but it was a damaged ear that

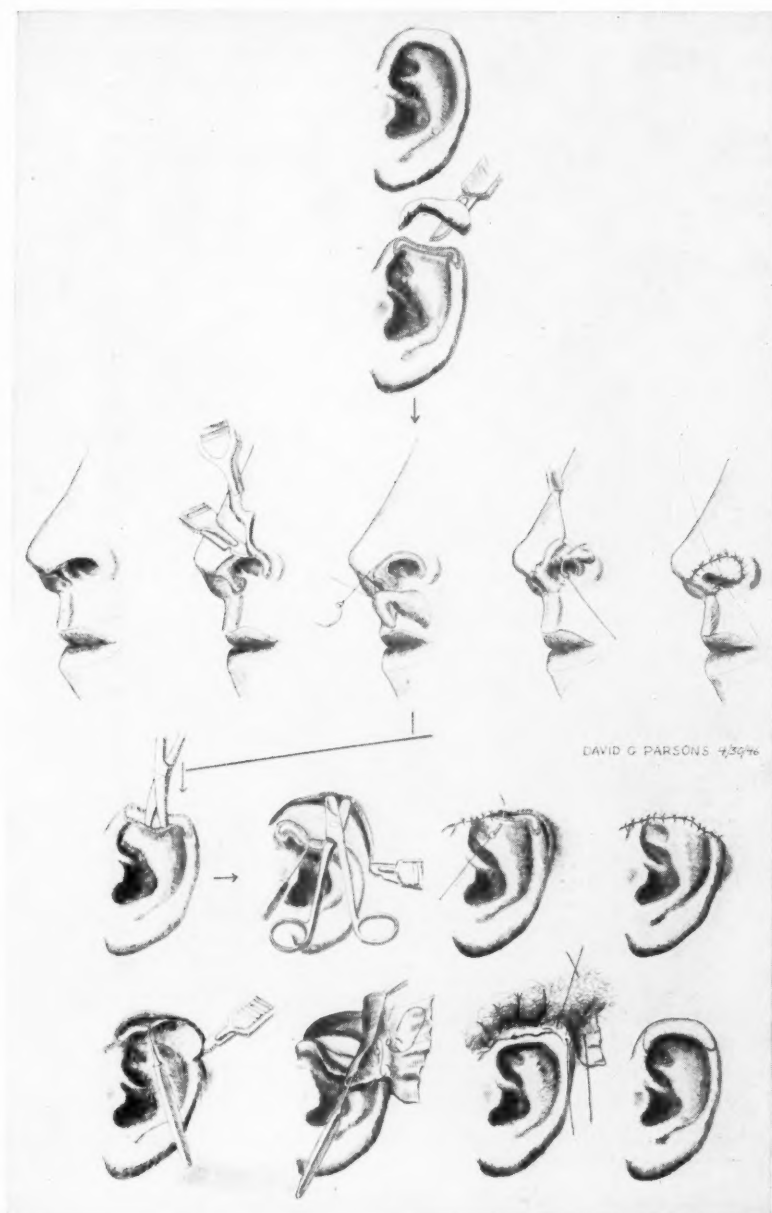


FIG. 2.—Reconstruction of ala, angle and columella with a single composite free graft in one single operation. Secondary freeing of the ear from the scalp flap. Patient shown in Figure 3.

the first one of these grafts was taken from, and Figure 4 shows the use of a burned ear.

Losses about the tip of the nose and the ala and the columella are the ones for which this graft is best adapted. While such a small loss as an ala, or a columella, or the tip of a nose may seem trivial to many (and perhaps especially to most members of this association), to the patient the defect is a serious one. This type of repair, done in a single operation,



FIG. 3.—Restoration of ala, angle, and columella in one operation, with a free composite graft from the ear. The ear is shown after the scalp flap has been loosened.

usually gives the best restoration and avoids the use of distant (or local) flaps with multiple operations and further scarring. Simple alar losses that can be repaired with rotation flaps from along the nasolabial fold are, of course, still done in this manner, and no dogmatic statements are intended as to the use of this procedure. It is simply recorded as a worth while possibility—labor-saving and rapid, and as possibly giving the most satisfactory results in many instances.

Since the original publication the use of the composite graft has been extended, larger grafts have been used (Fig. 6), triangular pieces have been

## COMPOSITE FREE GRAFTS

successfully set-in to enlarge generally contracted nostrils, more columellae have been added to or restored, and more double alar transplants have been done—*i. e.*, on both alae (Fig. 4). Defects of the whole ala around the tip and clear down the columella have been repaired in single operations with single composite grafts, as shown in Figures 2 and 3. In total burns of the nose it has been possible to resurface the whole nose with a free skin graft

FIG. 4-A

4-B

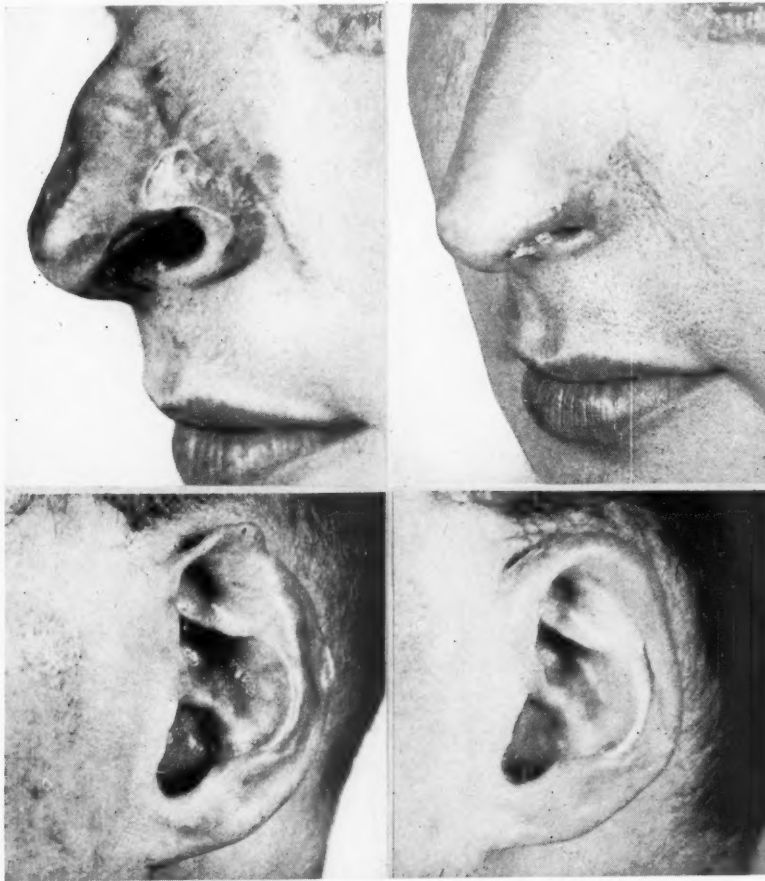


FIG. 4.—Total resurfacing of burned nose in single operation with a full-thickness graft from above the clavicle. Reconstruction of both alae later with free composite grafts from the ear at one operation.

Burned ear used for alar reconstruction and repair of ear after removal of graft.

and then put on ala with these grafts, thus, avoiding large distant flap restoration (Fig. 4). Also, of importance is the repair of small notches that formerly were collapsed and sutured or had flaps rotated down into place with additional scars. The tiny grafts used in these instances are trying of patience, but are worth while.

Small flat defects at the tip and flat losses of the columella have been repaired with flat grafts with one surface of skin and underlying cartilage (Fig. 5). These are most questionable of survival of all types and so far have been used of only small size. To provide columella there must be a septum left high up that can be opened for blood supply.



FIG. 5-A

FIG. 5-B

FIG. 5.—Restoration of columella in single operation with free composite graft from ear.

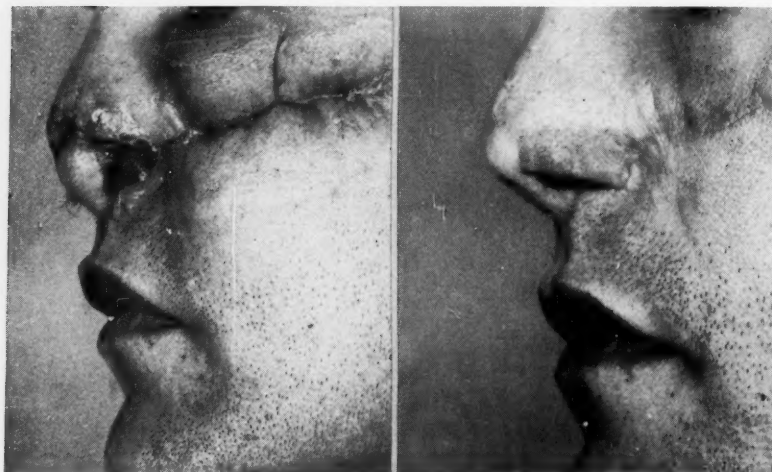


FIG. 6-A

FIG. 6-B

FIG. 6.—Large nasal restoration in single operation with large composite free graft from ear.

At operation, the defect is opened carefully, the edge scar discarded, and a good minute blood supply is opened into. This increases the size of the defect and if the contracted tissues need opening they are dissected back into place. An accurate pattern is taken with celluloid.

The pattern is marked out on the ear and the graft removed by careful through-and-through incisions, and especial care is taken not to dislodge the

## COMPOSITE FREE GRAFTS

skin from the cartilage, or to slide it off. The cartilage must be maintained as a composite part of the graft and not dislodged or loosened in its bed.

The graft is sewed accurately into place with fine white silk sutures at each end of the cartilage and then with fine interrupted silk sutures all around the edges, inside and out. The area is carefully packed and a firm pressure dressing applied, usually using an aluminum splint over soft pads.

The course of the graft is apt to be somewhat distracting with blueness and redness and often some blistering, but the survival rate is consistently good and other surgeons have given reports of satisfaction. The color of the graft is red for a good while and may possibly need permanent pigment injection, but so far this has not had to be resorted to.

The size of the transplants have been increased some, extra skin as a full-thickness graft has been taken over and beyond the cartilage. But great bulk probably can not be successfully transplanted consistently. The length does not make any difference, but the height or distance from the nutrient edge does.

This free transplantation of the composite graft points to the possibility that has been noted clinically occasionally of the successful replacement and grafting of completely severed parts of the ear. These losses of the ear should have attempted replacements locally if the tissues are clean enough and not too macerated. If they can not be restored locally, burying them in the subcutaneous tissues can be considered for possible later use. This conversely can also be applied to clean losses of parts of the nose, and it has been applied to, and recorded of, the tips of the fingers.

While the repair of defects of the nose are described here, the use of the graft in other areas is under investigation, such as the repair of deformities associated with cleft lip.

Sensation in these small grafts usually becomes normal if the supplying nerves are present in the area.

### SUMMARY

Drawings of operative procedures and illustrations of clinical results are shown of composite free grafts of two surfaces of skin and cartilage, from the ear, with restorations of the border of the nose and the columella in single procedures.



# UNUSUAL SURGICAL LESIONS OF THE UMBILICUS\*

## REPORT OF CASES OF CONGENITAL ORIGIN

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EVERY DISCUSSION of diseases of the umbilicus should begin with reference to the definitive work of Dr. Thomas S. Cullen,<sup>1</sup> published in 1916, because with the exception of additional case reports very little has been added to the subject. Previous to Cullen's book a senior member of this Association, Dr. George Tulley Vaughan,<sup>2</sup> reported a case of cyst of the urachus, collected 52 cases from the literature and presented a classification of abnormalities of the urachus.

During recent years many cases of congenital and acquired abnormalities associated with the umbilicus have been reported, the largest number in any one report being by Trimmingham and McDonald.<sup>3</sup>

The embryologic background for these conditions has been frequently presented but for clarity should be reviewed briefly. During the early days of the embryo the yolk sac is the largest structure. The allantois grows from it into the body stalk and at almost the same time there is an infolding of the yolk sac to form the primitive intestinal tract. The growth of the embryo includes this segment in its body cavity or celom. The segment of the yolk sac which connects its main portion with the primitive intestinal tract becomes the vitelline duct. The growth of the midgut is primarily in the section of the celom outside the cavity of the embryo. The debouched gut lies in the extra-embryonic portion of the celom in the proximal end of the developing umbilical cord, the so-called umbilical celom. At about 2.5 months of gestation when the embryo is 45 mm. in length the small bowel recedes into the body cavity. The vitelline duct normally separates from the ileum and becomes completely obliterated.

The allantois opens into the anterior face of the primitive cloaca. The primitive cloaca is divided into the rectum (posterior portion of cloaca) and the vesico-urethral primordium (anterior portion). The allantois persists at the cephalic end of the primitive bladder. As the bladder grows the allantois degenerates, a remnant persisting in the form of a fibrous cord, the urachus, connecting the apex of the bladder with the navel. The urachus is flanked by the hypogastric ligaments, remnants of the umbilical or hypogastric arteries.

The vitelline (omphalomesenteric) arteries fuse proximally to become the superior mesenteric artery. The superior mesenteric vein develops secondarily in connection with the left vitelline vein which becomes part of the

\* Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

## LESIONS OF THE UMBILICUS

portal vein. The parts of the vitelline veins distal to the anastomosis of the superior mesenteric and left vitelline vein degenerate as the yolk sac degenerates.

The closure of the abdominal wall to and around the umbilicus is a result of the growth and approximation of the ectoderm (epidermis) and mesoderm (derma, muscle, fascia, and peritoneum) and is relatively complete before the third month of gestation.

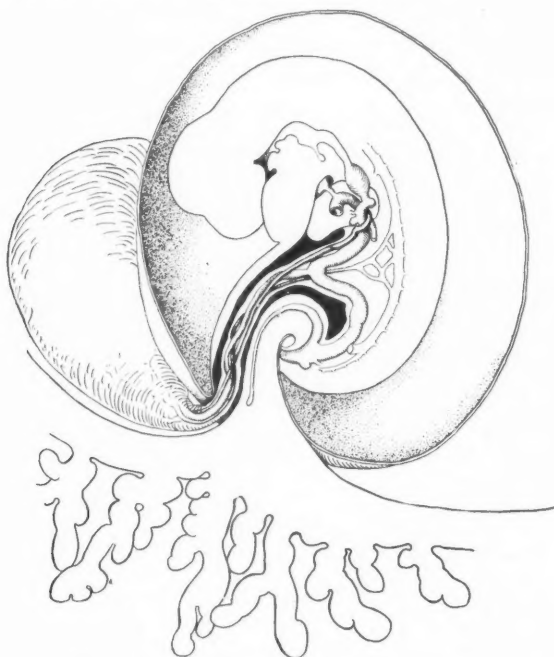


FIG. 1.—Five-millimeter human embryo, 33 days gestation  
(modified from Cullen).

The congenital abnormalities that occur in this region are results of faulty development. Figure 1 is a diagram of a 5-mm. embryo of about 33 days gestation. The allantois can be seen as a duct leading from the vicinity of the yolk sac through the primitive umbilicus to the cloaca. The vitelline duct connects the yolk sac and the small intestine (ileum) and the omphalomesenteric vessels accompany the vitelline duct. The midgut, consisting of the small intestine and the right side of the colon, is developing in the umbilical celom. The wall of the celom has grown and narrowed the ventral or umbilical defect in the celom to the primitive umbilicus which contains the umbilical celom.

After the cloaca has separated into the urinary bladder and the rectum, the allantois continues to connect the bladder with the umbilical cord. At birth the umbilical portion of the allantois has become obliterated. The abdominal portion is quite short and may be patent. As the bladder descends into the pelvis the duct or cord if it has closed, is drawn out in length.

Failure to obliterate may be complete or partial, and the persistence of all or part of this epithelial tube is the explanation of the conditions to be reported.

In the same manner the vitelline duct should separate from the ileum and degenerate. A persistence of all or part of this tube lined with intestinal mucosa explains certain congenital abnormalities.

As noted above the midgut should recede into the abdomen. If it is prevented from doing this, a hernia in the umbilical cord is present at birth. If there is a failure of the ectodermal and mesodermal structures to unite in the midline of the ventral surface of the embryo, a defect results which would be covered by amnion and peritoneum fused into a membrane.

#### ABNORMALITIES OF THE URACHUS

Vaughan,<sup>2</sup> in 1905, before this Association proposed the following classification of these abnormalities:

1. "The Complete, in which the duct is open all the way, forming a continuous communication between the bladder and the outside of the body at the navel.
2. "The Blind Internal, in which the navel remains closed, but the duct communicates with the bladder.
3. "The Blind External, in which the communication with the bladder is closed, but the navel end remains open.
4. "The Blind, in which both ends are closed, but the duct remains open in the middle."

The Complete ducts are the most interesting of this group. Usually urine is passed both by navel and by urethra. Occasionally there is obstruction of the urethra so that all of the urine is passed through the navel, more often the tract is small so that only a few drops of urine appear at the navel. In planning excision of such a tract it should be remembered that in the newborn the bladder has not descended into the pelvis so that the patent urachus is short.

**CASE I.—Patent Urachus:** W. J., white, male, an infant of nine months, was admitted to the Medical College of Virginia Hospital on December 4, 1945. He was a normal well-developed infant except for infection in and around the navel in the center of which was a sinus draining urine. He voided normally through the urethra. He was given penicillin intramuscularly, and wet dressings were applied to the infected area. After ten days the acute infection had subsided. He was then operated upon by Dr. W. F. Grigg, Jr., the Resident Surgeon. The navel was circumscribed by the incision which was extended downward in the midline. The duct was a thick cord, 4 cm. in length, adherent to the peritoneum, which had to be opened for its removal, and led to the dome of the bladder. Here it was ligated, cut away and the stump buried by silk sutures. The wound was closed in layers. On the seventh post-operative day the wound, which had become infected, disrupted, with evisceration of loops of small bowel. It was resutured and the patient then recovered uneventfully. Figure 2 illustrates this condition diagrammatically and Figures 3 and 4 show the microscopic picture of the urachus at two levels.

## LESIONS OF THE UMBILICUS

The Blind Internal urachus opening into the bladder is probably of very frequent occurrence and goes usually undiscovered through life. Hammond, Gylesias, and Davis<sup>4</sup> found an urachal sinus communicating with the bladder in 10 per cent of adult specimens examined by them. Calculi may be formed in these sinuses, and such cases have been reported by Dreyfuss and Fleiss;<sup>5</sup> Atcheson;<sup>6</sup> Bandler, Milbert, and Alley;<sup>7</sup> and Wyatt and Lanman.<sup>8</sup> The opening into the bladder may be small and the patent urachus above dilated so that it has the appearance of an accessory bladder or a diverticulum. Such a case was reported by Meade.<sup>9</sup>

The Blind External urachus opening at the umbilicus is rare. It may become infected and form an abscess. A case of tuberculous infection of such an urachus was reported by Winer and Danciger.<sup>10</sup>

The Blind Urachus usually results in the formation of one or more cysts. The size, number, and location of these cysts are determined by the amount and location of the persistent epithelium of the duct. They grow very slowly by accumulation of desquamated epithelium and secretion from the cells so they are usually manifested only in adults. The size varies from a few millimeters to enormous cysts which fill the abdomen. In the large cysts the epithelial lining has usually been destroyed.

Rarely they become malignant tumors (Cullen,<sup>1</sup> Payne and Jones<sup>11</sup>). These cysts frequently become infected and filled with pus; after incision and drainage a sinus may remain or the cyst may recur. (Kantor,<sup>12</sup> Dudgeon, Jr.,<sup>13</sup> Yoerg<sup>14</sup>.) An infected cyst which ruptured into the peritoneal cavity was reported by Powers.<sup>15</sup>

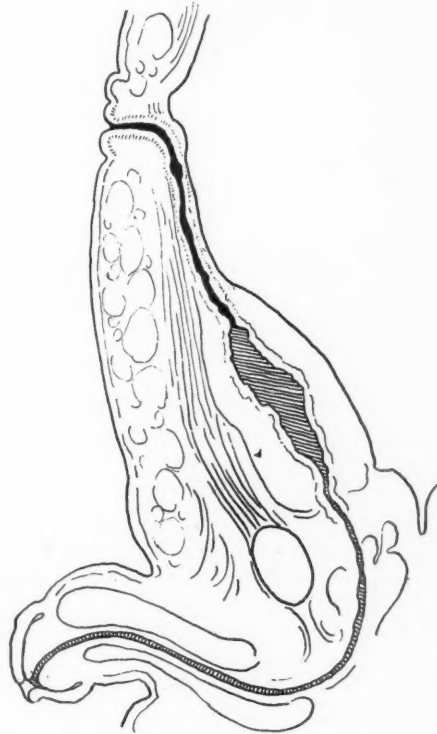


FIG. 2.—Urachus patent at birth.

**CASE 2.—Cyst of Urachus:** Mrs. A. B., an elderly white woman, was admitted to the Memorial Hospital. She presented a large abdominal tumor which had been present for several years without symptoms. Recently it had grown rapidly in size and caused pain. It was thought to be an ovarian cyst but at operation through a low midline incision the cyst was encountered before the peritoneum was seen. It was densely adherent to the abdominal wall and obviously could not be removed. It was opened and approximately 3,000 cc. of cloudy thick fluid was evacuated. The

FIG. 3

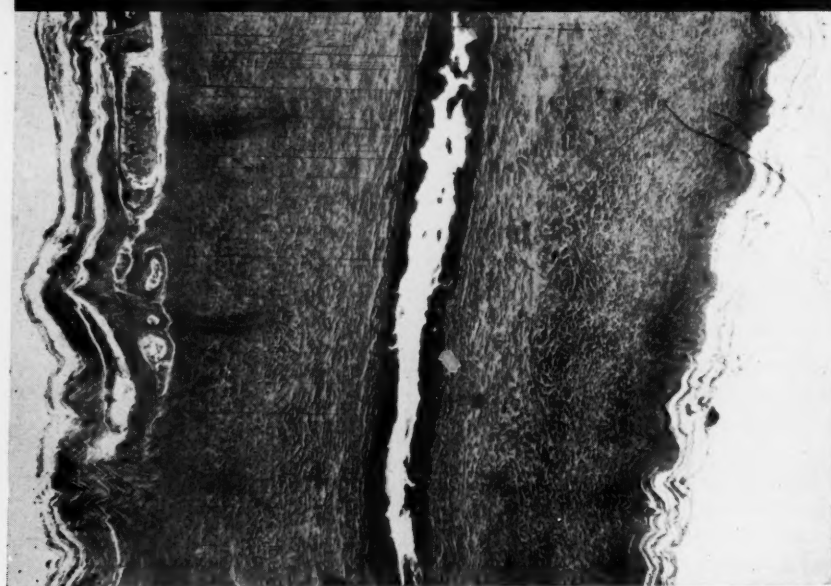
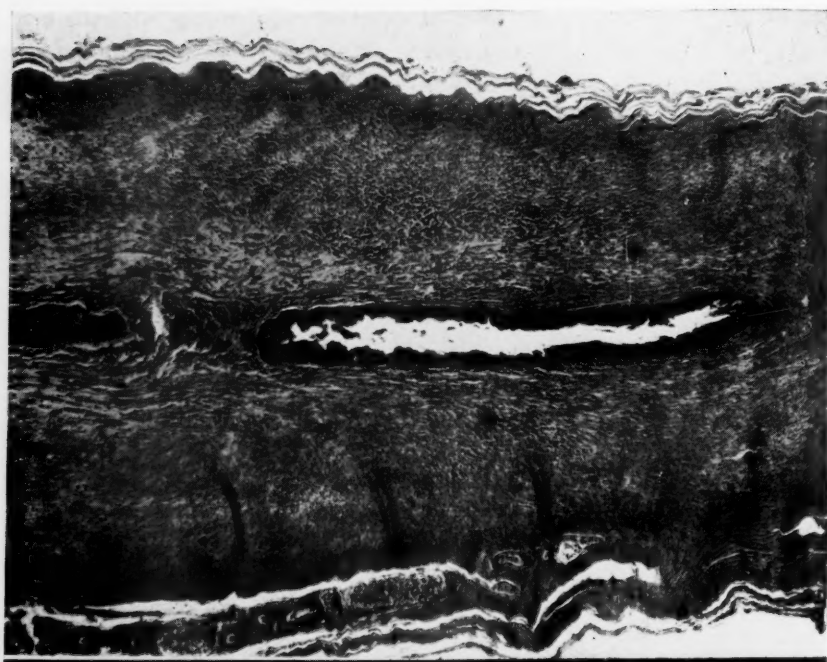


FIG. 4

FIG. 3.—Low power photomicrograph of patent urachus from Case 1.  
FIG. 4.—Another level of patent urachus from Case 1.



posterior wall of the cyst was obviously adherent to the peritoneum because coils of bowel could be identified through it. The entire incision was left open and the cavity packed with gauze. This packing was gradually removed the external opening was kept patent, and the whole wound healed completely in about eight weeks. Microscopic examination of tissue from the wall of the cyst showed infected granulation and fibrous tissue but no epithelium.

**CASE 3.—Cyst of Urachus:** Mrs. R. L. M., white, female, age 30, was admitted to St. Luke's Hospital May 16, 1935. She presented a large abdominal tumor which had gradually increased in size. This was thought to be an ovarian cyst and was explored through a long midline incision. The findings were the same as in Case 2 except that the fluid in the cyst was much thicker and no pus was found. The wound was left open and the cavity packed with gauze. It healed to a small sinus which opened into a cavity about 10 cm. in diameter. The navel was not removed at the first operation. The wound was reopened, the navel excised and the remains of the cyst packed with gauze. The cyst then became obliterated but the sinus persisted for about two years before it healed. Microscopic examination of tissue from the wall at both operations showed granulation and fibrous tissue with no epithelium. No connection between the navel and the cyst could be found.

Figure 5 shows, diagrammatically, the patent urachus closed at both ends which in adult life formed the large cysts illustrated in Figure 6.

**CASE 4.—Cyst of Urachus:** F. B. S., white, male, age 41, was admitted to the Stuart Circle Hospital on September 5, 1945. He complained of pain in the upper abdomen. Examination revealed a smooth mass about the size of a large grapefruit in the midabdomen. This mass was freely movable and not tender. The navel was normal. The abdomen was explored through a midparamedian incision. The tumor was a thin-walled cyst attached to the under side of the navel by reflection of the peritoneum. The urachus thinned and disappeared into the wall of the cyst and below, to the bladder, it appeared normally obliterated. The cyst measured 15 cm. in diameter and contained clear fluid. Microscopic examination of its wall showed fibrous tissue but no epithelium. Figure 7 shows, diagrammatically, the patent portion of the urachus responsible for this cyst and Figure 8 is a photograph of the cyst. Figure 9 is a photomicrograph of the wall of the cyst.



FIG. 5.—Diagram of urachus patent but closed at both ends. This duct may enlarge to a cyst in adult life.

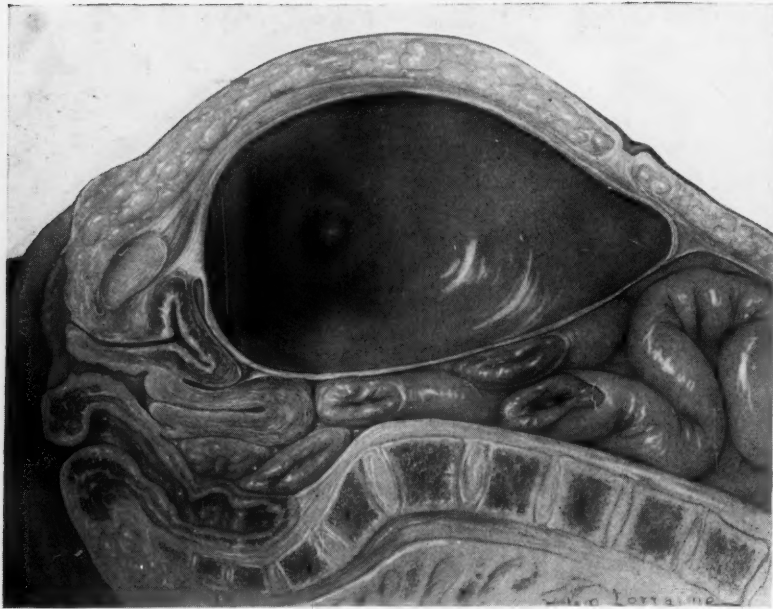


FIG. 6.—Drawing illustrating large cysts of urachus found in Cases 2 and 3.



FIG. 7.—Diagram showing the patent portion of the urachus which formed cyst from Case 4.

COMMENT: Excision of these lesions is the treatment of choice. They are frequently complicated by infection of the tract or cyst and operation should be delayed until the infection has been controlled. Abscesses of urachal cysts should be drained preliminary to excision because usually the peritoneum must be opened for excision. When the cyst has grown to large size excision is either impossible or too hazardous so marsupialization must be done.

#### ABNORMALITIES OF THE VITELLINE DUCT

The vitelline duct may remain patent from the navel to the small bowel, it may be obliterated at each end and form a cyst, small portions may persist in a cord and form small cysts, the external end may remain in and beneath the navel to form a

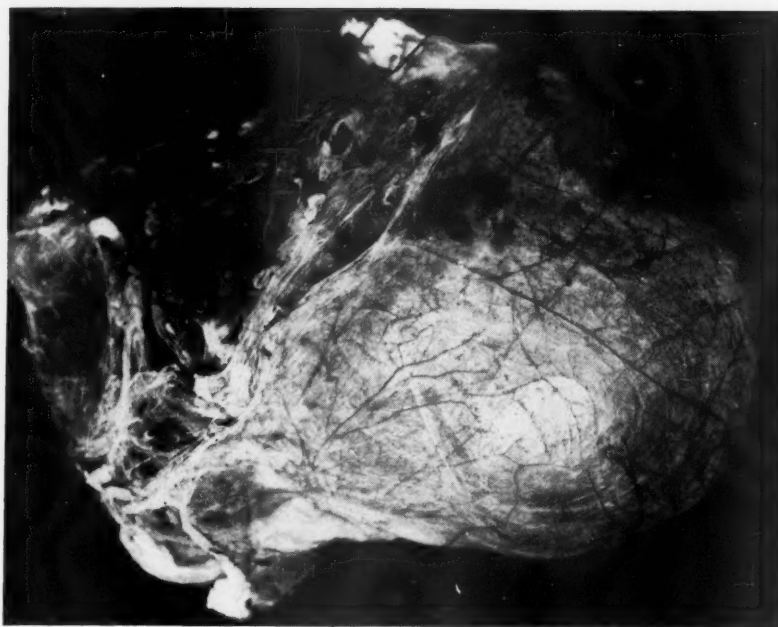


FIG. 8.—Photograph of cyst of urachus from Case 4, 15 cm. in diameter.

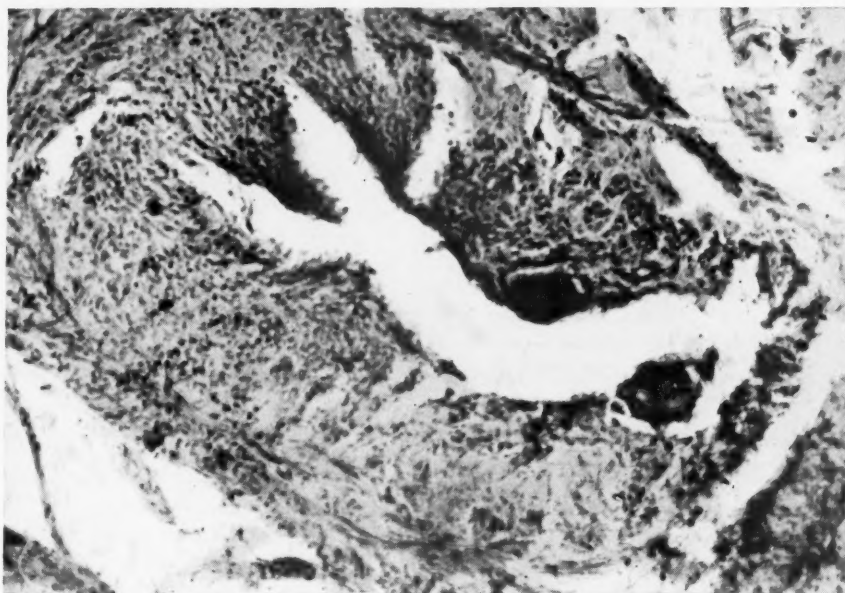


FIG. 9.—Photomicrograph of wall of cyst from Case 4.

sinus, a cyst or a small tumor (Fig. 10), it may remain as a cord attached at either or both ends, the blood vessels may remain as a cord, Buchanan and Wapshaw<sup>16</sup> and as occurs most frequently the distal end may remain to form the diverticulum of the ileum described by Meckel.

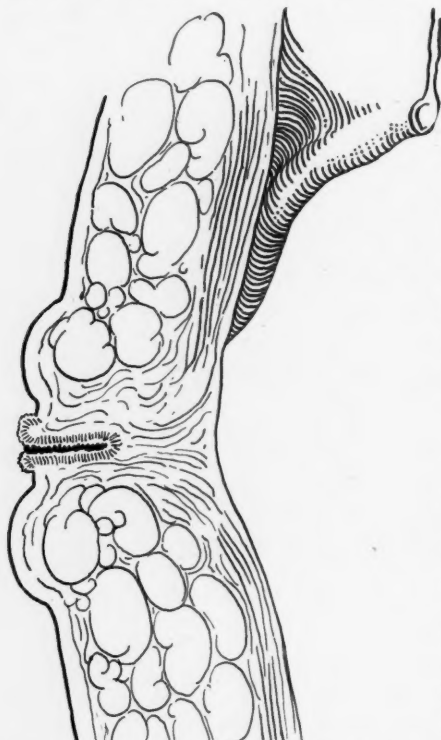


FIG. 10.—Diagram of remnant of the vitelline duct in the navel.

in the navel. No mass beneath the navel could be palpated. The diagnosis was vitelline duct cyst and the navel was excised through an elliptical incision. Microscopic examination showed small bowel glands (Fig. 13).

**COMMENT:** The presence of small glandular tumors or cyst of vitelline duct origin is sufficient evidence to indicate excision of the navel and exploration at least of its peritoneal surface. Caustics are not sufficient to destroy this tissue, and cauterization might easily result in penetrating the peritoneal cavity. There may also be other remnants deep in the navel or on its peritoneal surface, as in the case reported by Barney Brooks<sup>17</sup> which had pancreatic tissue beneath a small cyst. The small tumor may be the end of a more or less patent duct, as reported by Morgan,<sup>18</sup> or the end of a cord leading to a Meckel's diverticulum, as reported by Lange and Eastman-Nagle.<sup>19</sup>

**CASE 8.—Primary Carcinoma of the Umbilicus:** L. H., colored, female, age 65, was admitted to St. Philip Hospital on January 3, 1945. She complained of soreness and discharge from the navel of three months duration. Examination showed a deep

**CASE 5.—Vitelline Polypus of Umbilicus:** Baby V., white, male, age 2 years, was admitted to Stuart Circle Hospital on April 21, 1944. Since birth this baby had had a soft red area in the navel which bled easily. The mass was about 1 cm. in diameter and had the appearance of granulation tissue. Probing did not reveal a sinus and no mass could be palpated beneath the navel. Microscopic examination of the tissue taken for biopsy showed typical small bowel glands (Fig. 11). The navel was excised through an elliptical incision and there was no abnormality other than the small gland tumor.

**CASE 6.—Vitelline Polypus of Umbilicus:** Baby Miller, white, male, age 11 months, was seen on December 12, 1945. The history, examination and biopsy (Fig. 12), were identical with Case 5. He has not been operated upon on account of recurring upper respiratory infections.

**CASE 7.—Vitelline Cyst of Umbilicus:** Baby A. G. M., white, female, age 14 months, was admitted to Stuart Circle Hospital on October 11, 1945. Since birth this child had had a white discharge from the navel and on several occasions there had been acute infection. Examination showed a sinus leading into a cavity about 1.5 cm. in diameter

## LESIONS OF THE UMBILICUS

navel with an ulcer in its center measuring about 1 cm. in diameter, deep red in color. The edges were sharp and the whole area was very firm to feel (Fig. 14). There was no history indicative of intra-abdominal lesion and abdominal and pelvic examinations were negative. The navel was excised through a wide elliptical incision. The peritoneal surface of the navel was normal. A limited exploration of the abdomen revealed no evidence of malignancy. The pathologic diagnosis was adenocarcinoma

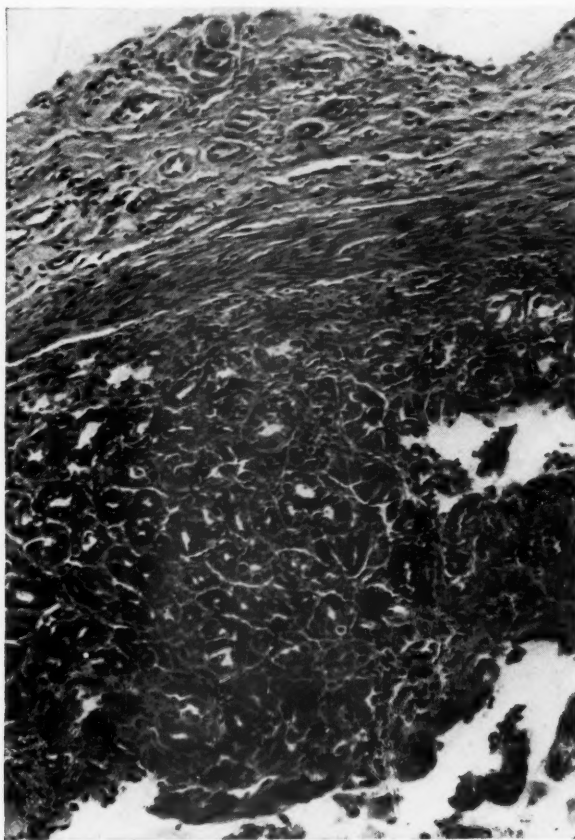


FIG. 11.—Photomicrograph of polypus from Case 5.

(intestinal type) (Fig. 15). Roentgenologic examinations of the gastro-intestinal tract after barium meal and enema were entirely negative. Her recovery was uneventful except for mild wound infection. Three months after operation a hard mass developed under the scar. Roentgenotherapy of this mass resulted in decrease in its size. Ten months after operation there was marked ascites and, after removal of 4,000 cc. of fluid, a firm mass could be felt beneath the navel extending upward in the right side. She died one month later at home. No postmortem examination was made.

COMMENT: This case seems to be one of primary adenocarcinoma of the navel from vitelline duct remnant, although incomplete exploration and lack of postmortem examination leave some doubt. In favor of its primary nature are the absence of history to indicate an intra-abdominal lesion, absence of physical signs, negative roentgenologic examination of the gastro-



intestinal tract, the local recurrence, and the infra-umbilical mass found after removal of ascitic fluid. Undoubtedly the majority of malignant lesions in the umbilicus are metastatic from primary intra-abdominal growths. I have explored two such cases. In one, the primary growth was in the

FIG. 12

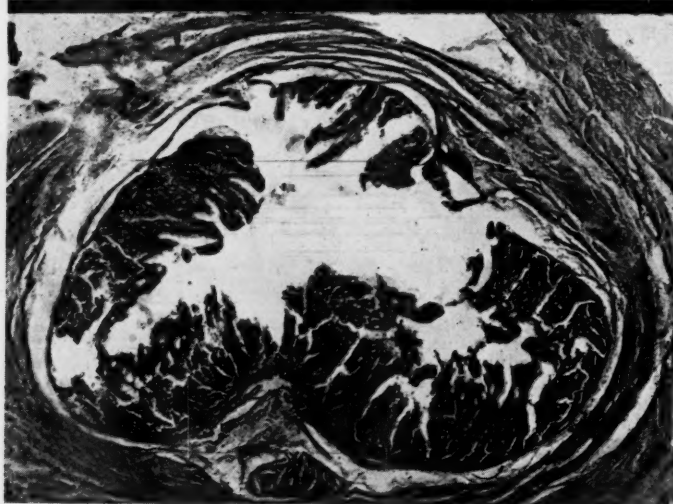
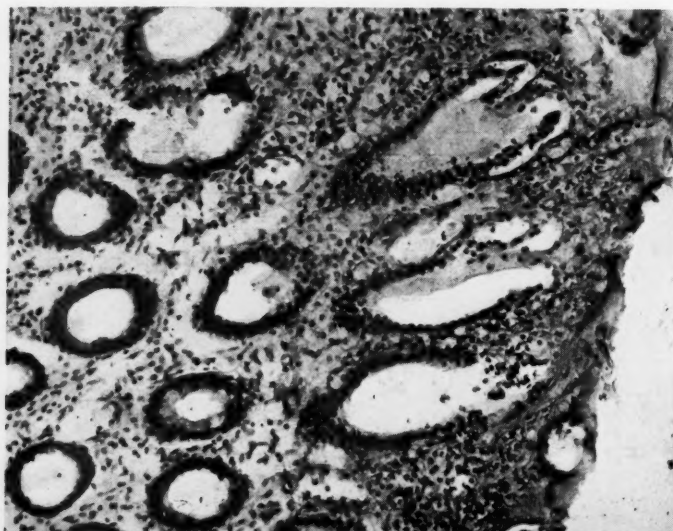


FIG. 13

FIG. 12.—Photomicrograph of polypus from umbilicus of Case 6.

FIG. 13.—Photomicrograph of wall of cyst from Case 7.

small bowel; in the other, it was in the left kidney; and both had metastases in the liver and omentum. Lombardi and Parsons<sup>20</sup> reported metastasis from the stomach, Rochet and Francillon<sup>21</sup> one from the bile tract, and Cullen<sup>1</sup> collected a number of cases both primary and metastatic.

## LESIONS OF THE UMBILICUS

### UNUSUAL HERNIAE AT THE UMBILICUS

The ordinary umbilical hernia is due to a defect in the fascia beneath the navel. The rare ones are due to gross abnormalities of embryonic development. Probably the most important factor is the failure of approximation of mesodermal structures. This may be due to large size or abnormal shape of viscera, particularly the liver, or to small volume of the abdominal cavity, or to some unknown factor in embryonic growth. Like other congenital defects it is at times one of multiple lesions.

CASE 9.—*Hernia into the Umbilical Cord*: Baby Y, Negro, male, age 6 days, was admitted to St. Philip Hospital on November 24, 1929. The baby was normally developed except for the presence of a mass in the stump of the umbilical cord measuring 7.5 x 6 cm. Its wall had the appearance of a huge umbilical cord which was bile-stained, necrotic in spots, and ulcerated over the distal portion, where there was a fecal fistula (Fig. 16). At operation, a transverse elliptical incision was made around the umbilicus, and the peritoneum opened. Numerous coils of small bowel were in the sac. They were adherent to its wall and to each other by fibrinous adhesions. The peritoneum was deeply congested and edematous. At the distal end of the sac a Meckel's diverticulum



FIG. 14.—Drawing of the malignant ulcer in Case 8.

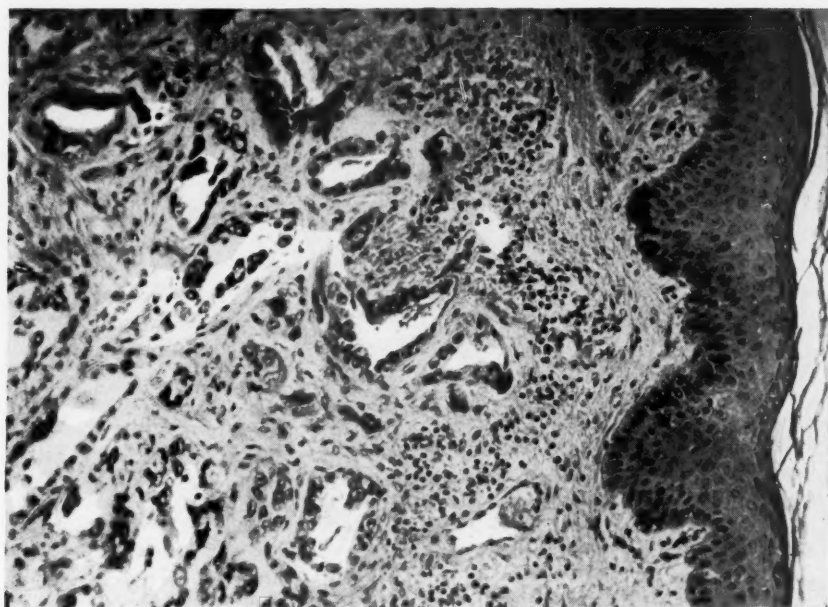


FIG. 15.—Photomicrograph of tumor of navel Case 8 showing adenocarcinoma.



FIG. 16.—Photograph of Case 9.

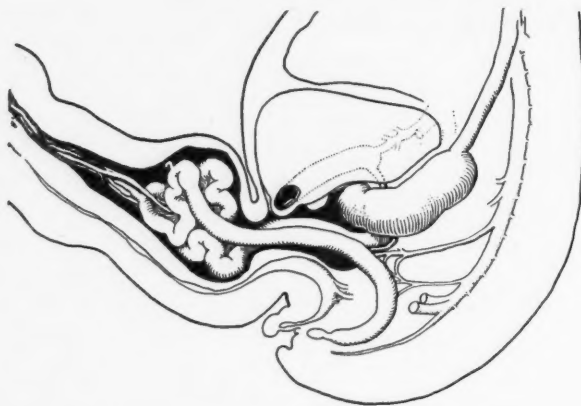


FIG. 17.—Diagram of 23-mm. embryo, this normal embryonic location of the midgut remained at birth of Case 9.

was present which was open through the wall of the mass. The adhesions were separated, the diverticulum amputated, and the coils reduced into the peritoneal cavity. The umbilical defect was closed by overlapping the wall, as in the repair of an ordinary umbilical hernia. The baby made a good recovery, except for thrush infection in its mouth, and left the hospital on the 12th postoperative day.

COMMENT: As previously noted the small bowel is developed in the exocoelom located in the proximal end of the umbilical cord. When the embryo is 2.5 months of gestation, the bowel normally recedes into the ab-

## LESIONS OF THE UMBILICUS

dominal cavity and the exocoelom is obliterated. In this case the vitelline duct was adherent or too short to allow the bowel to recede, so that the embryonic state remained. When the cord was cut distal to the mass the duct was divided leaving the fecal fistula. The Wharton's jelly which forms the wall of this hernia in the cord degenerates soon after birth. It is, therefore, important to operate as soon after birth as circumstances permit. Figure



FIG. 18.—Drawing of Case 10, showing the abdomen covered by a thin transparent membrane.

17 illustrates, diagrammatically, the state in a 23-mm. embryo of 47 days. This remained at birth in this case and explains the hernia into the umbilical cord.

**CASE 10.—Amniotic Hernia:** Baby W, Negro, female, age 2 days, was admitted to St. Philip Hospital on September 24, 1929. The baby had taken feedings vigorously and had passed normal stools and urine. It was well-nourished and well-developed except for the defect on the anterior abdominal wall. There was a circular window, about 7.5 cm. in diameter, covered by a thin transparent membrane through which the liver and the intestines could be clearly seen. The stump of the umbilical cord was attached at its lower portion. There was no protrusion of the abdominal contents (Fig. 18).

When the baby arrived in the operating room the next day, its temperature, which had previously been normal, was 100.6° F., and the membrane over the abdomen had become yellow and opaque. There was obviously infection present, but closure of the defect seemed imperative. In order to prevent opening the peritoneal cavity a circular incision was made leaving about 0.5 of skin attached to the edge of the membrane. The surrounding skin was undermined and sufficiently mobilized to allow easy union down the midline.

The baby's condition declined rapidly and it died 12 hours after operation. Post-mortem examination showed a pocket of pus within the membrane and general peritonitis. The only abnormalities noted in the viscera were a globular shape to the liver which was normal in weight (12 Gm.) and partial failure in rotation of the right side of the colon.



FIG. 19.—Drawing of Case 11 showing omentum protruding through a complete defect in the abdominal wall.

COMMENT: This deformity is a very interesting one. It is a rare condition but occurs with sufficient frequency for surgeons and obstetricians to be familiar with the dangers associated with it. Johns<sup>22</sup> recently reported such a case operated upon immediately after birth, and the baby survived. He reviewed the literature and collected 96 cases. The majority of cases have visceral deformities

and enlargements which made closure difficult and at times impossible. The case reported here would have been a very favorable one because there was no bulging of the covering membrane from such visceral abnormalities and closure was easy. However, the delay in hospitalization after delivery and the day in the hospital before operation gave the opportunity for development of infection of the membrane and the peritoneum which caused its death.\*

CASE 11.—*Complete Defect through the Abdominal Wall:* Baby P, white, male, was delivered at the Medical College of Virginia Hospital on July 28, 1945. At birth a yellow-red protrusion presented to the right of a normal umbilical cord. The next morning the protruding mass had increased in size; it measured 2 x 7 cm., was deep red in color, firm to feel, and narrowed at its point of emergence through the abdominal wall to the size of the opening, about 1 cm. Gentle traction brought out what was obviously normal omentum. There was also marked diastasis of the rectus muscles above the umbilicus (Fig. 19). A transverse elliptical incision was made excising the umbilicus and the opening. The pedicle of the mass of omentum was close to the transverse colon but it was easily excised. The transverse wound was closed as is usually done for an ordinary umbilical hernia. There was no other abnormality noted. This baby made an uneventful recovery.

COMMENT: There is no satisfactory embryologic explanation for this

\* Case 9 and 10 were reported in Surg. Clin. North America, 10, 805-809, August, 1930.



## LESIONS OF THE UMBILICUS

defect. I am not aware of any similar case reported, but the literature has not been completely reviewed.

### CONCLUSIONS

These cases and many others in the literature indicate the following conclusions:

1. The patent urachus and cysts of the urachus are frequently infected, this infection should be controlled by appropriate measures before radical operation is undertaken because it is usually necessary to open the peritoneum in excising the urachus or its cysts.
2. Large cysts should be marsupialized because complete excision is hazardous or impossible.
3. The frequency of patency of the urachus near the bladder indicates care in preserving its continuity when incisions are made near it, and if it is divided as in transverse incisions it should be carefully ligated to prevent possible leakage of urine into the peritoneal cavity.
4. The navel containing remnants of the vitelline duct should be completely excised because the tract extends deeply into the navel and is frequently associated with an abdominal persistence of the duct or its blood vessels.
5. Adenocarcinoma of the navel while more frequently metastatic may be primary.
6. Babies with amniotic hernia, hernia into the cord, and eventration of abdominal contents through the wall should be operated upon immediately after birth before infection has developed.

### BIBLIOGRAPHY

- <sup>1</sup> Cullen, T. S.: *The Umbilicus and Its Diseases*. W. B. Saunders Co. 1916.
- <sup>2</sup> Vaughan, G. T.: Patent Urachus. *Trans. Amer. Surg. Assn.*, **23**, 273, 1905.
- <sup>3</sup> Trimingham, H. S., and McDonald, Jr.: Congenital Anomalies in Region of Umbilicus. *Surg., Gynec. and Obst.*, **80**, 152, February, 1945.
- <sup>4</sup> Hammond, G., Gylesias, L., and Davis, J. E.: Urachus Anatomy and Associated Fascia. *Anat. Rec.*, **80**, 271-287, July 25, 1941.
- <sup>5</sup> Dreyfuss, M. L., and Fliess, M. M.: Patent Urachus with Stone Formation. *Journal Urology*, **46**, 77-81, July, 1941.
- <sup>6</sup> Atcheson, D. W.: Patent Urachus: A Report of Two Additional Cases. *Journal Urology*, **51**, 424, April, 1944.
- <sup>7</sup> Bandler, C. T., Miebert, A. H., and Alley, J. L.: Urachal Calculus: A Consideration of Associated Pathology of Urachus in Adult Life. *N. Y. State J. Med.*, **42**, 2203-2209, December 1, 1942.
- <sup>8</sup> Wyatt, T. M., and Lanman, T. H.: Urachus Calculus: Case with Enuresis. *Am. J. Roent.*, **43**, 673-675, May, 1940.
- <sup>9</sup> Meade, H. S., Urachus Cysts, Complicating Prostatectomy: Case. *Irish J. M. Sc.*, 6th Series, 32-33, January, 1941.
- <sup>10</sup> Winer, J. H., and Danciger, J. A.: Urachus Tuberculosis, with Extensive Intestinal and Peritoneal Tuberculosis. *Amer. J. Dis. Child.*, **61**, 539-546, March, 1941.
- <sup>11</sup> Payne, R. L., and Jones, R. D.: Neoplasm of the Urachus. *Va. M. Monthly*, **58**, 90, 1931.

- <sup>12</sup> Kantor, H. L.: Cysts of the Urachus. *ANNALS OF SURGERY*, **109**, 277, February, 1939.
- <sup>15</sup> Dudgeon, H. Jr.: Urachus: Treatment of Patent Urachus: Report of Seven Cases. *Surg., Gynec. and Obst.*, **71**, 302-306, September, 1940.
- <sup>14</sup> Yoerg, O. W.: Urachus Cysts. *Minn. Med.*, **25**, 496-501, June, 1942.
- <sup>15</sup> Powers, H. J.: Patent Urachus with Chronic Suppuration. *M. Bull. Vet. Admin.*, **18**, 446-448, April, 1942.
- <sup>16</sup> Buchanan and Wapshaw: Remnants of Vitelline Vascular System as a Cause of Intestinal Obstruction. *Brit. J. Surg.*, **27**, 533, 1939-1940.
- <sup>17</sup> Brooks, B.: Umbilical Teratoma. *ANNALS OF SURGERY*, **37**, 603, 1919.
- <sup>18</sup> Morgan, J. E.: Patent Omphalomesenteric Duct: Review of Literature and Case Report. *Am. J. Surg.*, **58**, 267-274, November, 1942.
- <sup>19</sup> Somerville-Large, C., and Eastman-Nagle, D.: Vitelline Duct: Persisting Remnants (Umbilical Cyst and Meckel's Diverticulum). *Brit. J. Surg.*, **29**, 271-273, October, 1941.
- <sup>20</sup> Lombardi, L. E., and Parsons, L.: Carcinoma of Umbilicus Metastatic from Carcinoma of Stomach. *Ann. Int. Med.*, **22**, 290, February, 1945.
- <sup>21</sup> Rochet and Francillon, M.: Cancer of Umbilicus: Metastasis from Biliary Tract. *Lyon. Med.*, **167**, 239, March 29, 1942.
- <sup>22</sup> Johns, F. S.: Congenital Defect of the Abdominal Wall in the Newborn. To be published in the *ANNALS OF SURGERY*.

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## BOOK REVIEW

**OPERATIVE GYNECOLOGY.** By Richard W. Te Linde, M. D. J. B. Lippincott Co., Philadelphia, Pa., 1946.

In a new "Operative Gynecology" Dr. Te Linde has produced an original work which, in the experience of this reviewer, is unique among surgical treatises on gynecology. The author apparently planned his work without regard to previous methods of presentation of the subject, and has produced what may well be a new classic on the subject.

In preliminary chapters he discusses in detail preoperative and postoperative care, the instruments employed and anesthesia. Each of these chapters is carefully illustrated and gives complete instruction on patient care and the development of particular procedures.

The later chapters are based not primarily on specific technical procedures but on the various organic conditions for which gynecologic operations are needed. The book becomes, therefore, of value not only because of its description of surgical technics but also for the clinical consideration of the various conditions to be treated.

Retrodisplacement of the uterus, for example, is considered first, from the standpoint of anatomy and then symptomatology, before the various surgical procedures are taken up. Similar handling is given to other subjects, as prolapse, the relaxation of the pelvic floor, and the various tumors. Pathologic consideration is given to the nonmalignant lesion of the cervix, to cancer of the cervix, the histology of the endometrium, and endometriosis, before the technical aspects of the surgery of these lesions is taken up. Ovarian tumors are discussed as a subject instead of there being simply a consideration of ovariectomy. Other chapters are devoted to surgical conditions close to but not in the immediate field of gynecology, namely, the surgery of the abdominal wall, of the anus, intestines, and the appendix.

The whole work is magnificently illustrated, principally with new drawings. The approach to the subject is an entirely fresh one, and Dr. Te Linde has made a most important contribution. The work will probably remain for a long time a standard and, perhaps, the principal work on gynecologic surgery.

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# STUDIES ON THE EFFECTS OF ADULT ANIMAL TISSUE EXTRACTS ON WOUND HEALING\*

A PRELIMINARY REPORT OF THE FACTORS RESPONSIBLE

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IN NORMAL HEALTHY INDIVIDUALS who have sustained injuries to tissue or organs, the process of repair proceeds through an apparently orderly sequence of biologic events to the point of healing, where the speeding-up of regenerative processes stops. The work here presented is based upon the assumption that it may be possible to influence this cycle directly in one or more of its phases, in order to accelerate the healing process.

This hypothesis is not new for, in 1925, Baker and Carrel<sup>1</sup> reported an apparent growth-accelerating effect of embryo-web porridge evident both *in vitro* and *in vivo* experiments. Other investigators also demonstrated an accelerating effect of embryonic extracts on wounds. However, during this period it was felt that if growth-promoting substances were present in tissues there should be more in embryonic cells.

In 1939, in a series of *in vitro* experiments it was shown by one of us (R. S. H.), and others,<sup>16</sup> that adult animal extract, has a greater stimulating effect than embryonic juices, and that this effect is not only present on standard chick fibroblast cultures but is noticeable on explanted human epithelium.<sup>10</sup> Furthermore, it was found that adult animal tissue extracts of sheep, beef, rabbit and dog were as effective on chicken fibroblasts as were homologous extracts.

It was logical, from the results of these *in vitro* experiments, to assume that clinical use might be found for the various extracts of tissue when applied to human wounds. From 1925 to 1932, many workers<sup>2, 5, 19, 22, 24, 25, 28</sup> used embryonic extracts of various tissues in an attempt to accelerate healing of so-called indolent wounds. However, the accompanying case reports are few and unimpressive. Furthermore, during this period less was known of the many systemic factors which influence final repair; hence, the criteria for refractivity were not sufficiently exacting. At the beginning of World War II interest in embryonic extracts was again revived when Waugh,<sup>20</sup> in 1940, reported beneficial results in refractory human wounds to which a desiccated embryonic extract prepared by Fischer<sup>13</sup> was applied. More recently, in 1945, reports from Russia, by Goldberg,<sup>14</sup> describe successful treatment of indolent wounds with an ointment containing embryonic extract.

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\* This work was supported by a grant from the Josiah Macy Foundation.

Read before the American Surgical Association, April 2-4, 1946, Hot Springs, Virginia.

Objections to the embryonic extract however have been raised since it is difficult to prepare in quantity, expensive, relatively unstable, and, as pointed out, it has less stimulating effect than have adult extracts.

In a series of experiments and clinical trials we have used a tissue extract prepared as follows: Sterile adult sheep hearts are finely minced in a blender with Tyrode's solution. After standing in the refrigerator for 24 hours the mixture is centrifuged and the supernatant extract decanted into convenient sterile flasks. This extract when kept refrigerated maintains its activity for one month, while a lyophilized ether-extracted fraction is active for a year. Both types of extracts were used in these experiments and were tested for potency.

As previously reported by us,<sup>17</sup> in 1944, the effect on dogs was studied by using bilateral areas of skin excision, one of which was treated with extract and the other by saline packs. It was found that in every animal the treated side was healed before the control in an average of 40 per cent less time (Chart 1).

At the same time, a number of clinical wounds were being treated, particularly those which appeared to be indolent or refractive to other types of treatment. Friendly skeptics would rarely call us to treat a wound until all other more orthodox methods had apparently failed. It soon became apparent that there was a definitely beneficial effect, which was obvious to many clinical observers. Concurrently, investigators<sup>26, 21, 18</sup> abroad were also using adult extracts or fractions thereof on indolent wounds, with reported success. Kerr and Werner<sup>18</sup> in this group used extremely exacting criteria for their selection of cases, but again interpretation of results, however objective, was based on clinical impressions.

Carrel and Hartmann,<sup>6</sup> in 1916, showed that wounds followed a definite pattern in healing, which could be expressed in a graphic curve, and DuNouy<sup>12</sup> in the same year pointed out that this curve could be expressed in a mathematic formula.

$$S' = S [1 - i(t + \sqrt{T+t})] \text{ or } S' = S [1 - i(t + \sqrt{nt})] \text{ (If } t \text{ is constant)}$$

Key:  $S'$  = area  $t$  days later.

$S$  = wound area at a known time.

$T$  = age of wound from time of first observation  $S$ .

$t$  = time between measurements.

$n$  = number of time-periods.

$i$  = a fixed coefficient which depends on the size of the wound and the age of the patient.

These observations were made on many carefully studied wounds which were followed to final healing.

In an effort to find some type of control for our treated clinical wounds, their expected healing time was plotted by the use of the above formula, and contrasted with the actual healing time of the extract-treated wounds. The results (Charts 2 and 3) appear to validate the clinical impressions. Furthermore, in a few instances, we were fortunate enough to obtain patients with bilateral lesions in comparable body areas. Using one wound for a control and

# WOUND HEALING

treating the other with extract, again a favorable difference was noted (Chart 4).

In this connection, Kerr and Werner<sup>18</sup> have concluded that upon the application of their extract "to one of several coexistent indolent wounds the process of healing resulting in the treated wound has been accompanied by the commencement of healing in others." They suggest that the absorption of the growth-stimulating substance at the primary wound may be responsible or that, as Young, Fisher, and Young<sup>30</sup> suggest, a growth-stimulating substance is liberated in the course of healing. We have found that in cases of multiple lesions, one may be stimulated to healing, while others remain relatively refractory.

Finally in an effort to evaluate the assumed stimulating effect of adult animal tissue extract without relying on clinical impression, secondhand controls or animal experiments, a group of five human volunteers were obtained for study. These subjects ranged in ages from 30 to 50 years, were in excellent nutritional states, and were all at absolute bed rest.

Under novocaine anesthesia, and complete sterile precautions, wounds were made on both anterior thighs of nearly equal size and depth. These varied from 3 to 4.5 sq. cm., and from simple complete skin excision, to removal of a block of tissue down to the deep fascia. After 48 hours the larger side was chosen for treatment and the contralateral lesion was used for a control method which consisted of constant dakinization. Dressings were done twice daily. The treated side was dakinized for 10 to 15 minutes and then flushed with saline. Following this an extract-saturated gauze square was placed in contact with the lesion and covered with paraffined gauze. The control lesion was treated by leaving a Dakin pack on the wound without washing with saline. It should be stated that under this therapy, there was no evidence of infection present in these wounds at any time. At regular intervals the surface circumference of these wounds was traced on a transparent plastic disk, the area measured with a planimeter and the wound sizes were marked on graphs (Charts 5, 6, 7, 8 and 9) so that the healing in both wounds in each individual could be followed. Obviously, by this method, no provision was made for volumetric measurement particularly in those subjects in whom deep blocks of tissue were removed.

Four of the five treated wounds were healed before the controls, and in

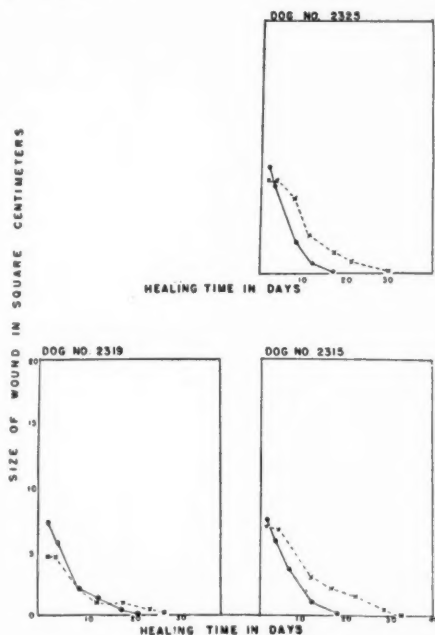


CHART I.—Graphs showing three of the animal experiments. The black line represents the treated wound and the dotted line the controls.



one case healing was simultaneous. In this subject (Chart 7), there appeared to be a mechanical impediment to epithelization. It had been noticed in observing the healing of some clinical lesions, particularly those which were deep and required filling in before epithelization, that the extract had a marked stimulating effect on granulation tissue growth. It was felt that the apparent accelerat-

CHART II

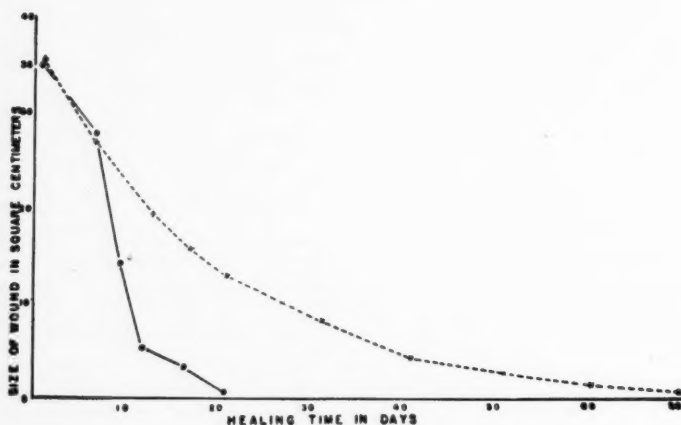
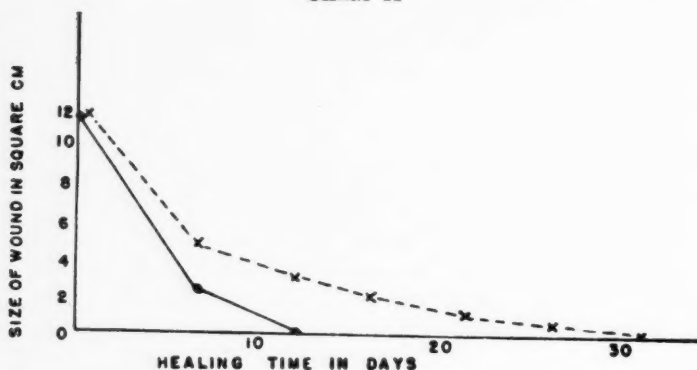


CHART III

CHART II.—Case of E. K.: Solid line shows the actual healing time and the broken line represents the expected healing time. (DuNouy)

CHART III.—Case of A. W.: Solid line shows the actual healing time and the broken line the expected (DuNouy) healing curve.

ing effect of the extract in these wounds was due in part to the relative rapidity with which granulation tissue filled cavities. Accordingly, in the last two of the volunteers, blocks of tissue were excised to the deep fascia, and in these cases granulations were flush with the skin long before the control, and the epithelium had consequently crossed the denuded areas faster. In one case, where only full-thickness skin was excised, the excessive granulating effect was observed to impede the epithelization process, requiring actual excision of granulation tissue several times.

DISCUSSION.—From a survey of the literature it would seem that the

# WOUND HEALING

CHART IV

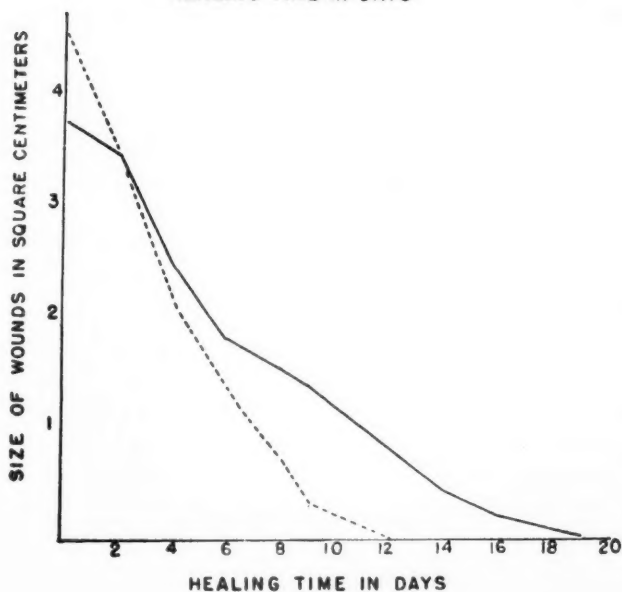
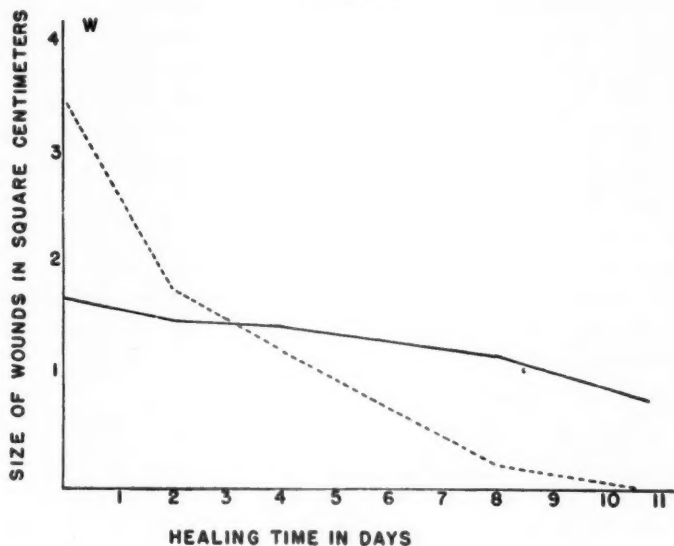


CHART V

CHART IV.—Case of W. (Patient with bilateral leg ulcers): The dotted line represents the healing curve of the treated lesion, and the solid line the control. The treated wound although over twice the size of the contralateral lesion was healed before the control showed much evidence of beginning healing. Notice that the untreated control side shows very little evidence of stimulation.

CHART V.—(Human Volunteer No. 1): Showing the decreased healing time of the treated wound (dotted line) as compared with the control (solid line).

approach to the problem of wound healing has been largely an attempt to find and eliminate factors which can be shown to interfere with the healing of open wounds. It has been amply pointed out<sup>4</sup> that when a wound ceases to heal or remains stationary there may be a number of reversible conditions at play. The nutritional state of a person, with particular reference to protein and certain vitamins, must be maintained at a normal level and hematologic abnormalities corrected. Metabolic diseases such as diabetes and local circulatory disturbances play a part, and must be controlled before normal wound healing may take place. Finally, it is well known that the presence or absence of infection is of paramount importance, for the process of tissue repair will not take place when there is overwhelming local suppuration. Consequently, many of the medicaments which purport to accelerate wound healing are in fact agents which attempt to control local infection, thereby enabling the normal biologic healing sequence to intervene.

Certain other substances claimed to have growth-promoting properties are found in the literature. Some of these, such as chlorophyll,<sup>27</sup> allantoin,<sup>15</sup> preparations liberating sulfhydryl groups,<sup>23</sup> creatine<sup>7</sup> and, recently, human bone marrow antiserum<sup>3</sup> are presumed to have growth-stimulating properties acting in a positive manner on indolent wounds, rather than by neutralizing inhibiting factors. Many of these substances have not been proven to be active on cells growing *in vitro*, nor do some of the clinical cases treated meet the requirements necessary to draw conclusions.

As a working hypothesis, it may be stated that the process of repair begins with tissue damage. It would seem plausible, therefore, to assume that from injured cells a substance or substances are liberated which may initiate or influence the physical and chemical reactions of cellular proliferation. It has also been noticed both in cells growing *in vitro*, and wounds, that there is an initial quiescent or lag-period during which no cell growth takes place, normally of at least 48 hours' duration. Furthermore, it is certainly obvious that mature cells in an organism are subject to control by a local inhibitory mechanism which may oppose indiscriminate cell multiplication. Supportive evidence for this latter hypothesis may be found in the fact that malignant unlike normal cells exhibit no such latent period when growing *in vitro*.<sup>11</sup>

In other words, as an hypothesis, it may be assumed that tissue stability is a unique balance between local stimulating and inhibiting factors, with the latter normally in control. It may be that on injury stimulating substances are released locally, and become the preponderant force, thus, initiating the reparative process. Possibly, as a wound nears completion of healing the titer of stimulating substances falls off or the inhibiting factors assume more importance. Hence, in indolent wounds, it may be that the period of stimulation started by the release of local factors may cease and the healing process remains stationary either because the stimulating substances are used up, or inhibiting factors predominate. Evidence for this theory has been noted in the marked stimulation and improvement when indolent wounds are treated as compared to the lesser acceleration, possibly additive in effect, when freshly acquired wounds in healthy individuals are used.

# WOUND HEALING

CHART VI

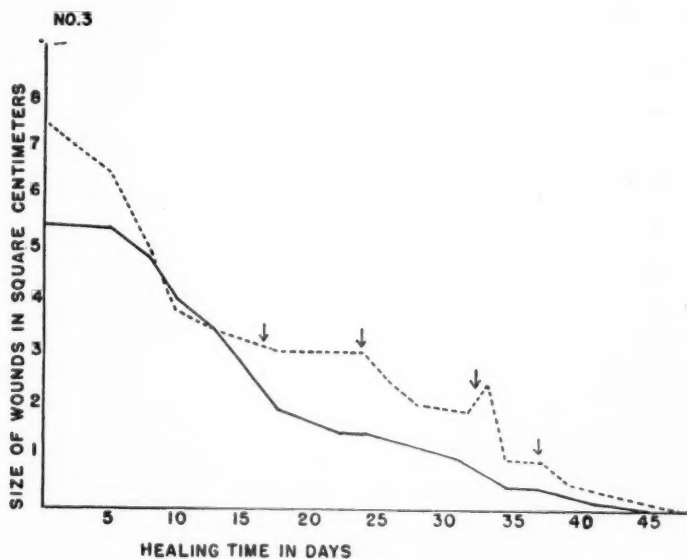
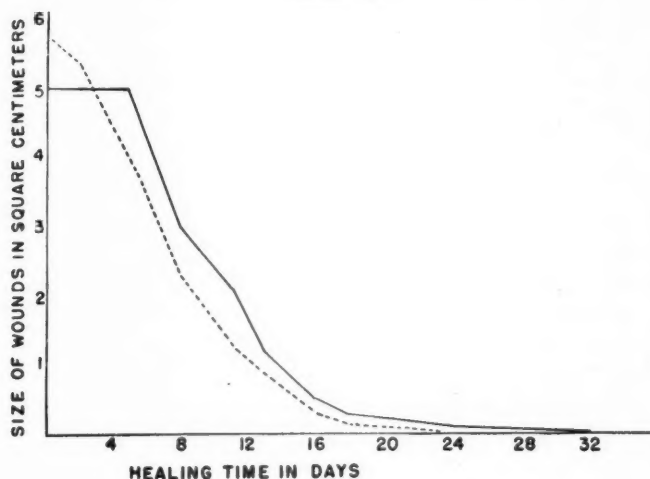


CHART VII

CHART VI.—(Human Volunteer No. 2): The broken line shows the healing time of the treated wound and the solid line that of the control.

CHART VII.—(Human Volunteer No. 3): The broken line represents the healing time of the treated wound and the solid line that of the control. The arrows point to periods of excessive granulation which mechanically impeded epithelization. Granulations were excised at these points.

Consequently, we feel that in adult animal tissue extract there is a substance (or substances) that exerts a growth-promoting effect when added to any heterologous tissue either *in vitro* or in human wounds. We further feel

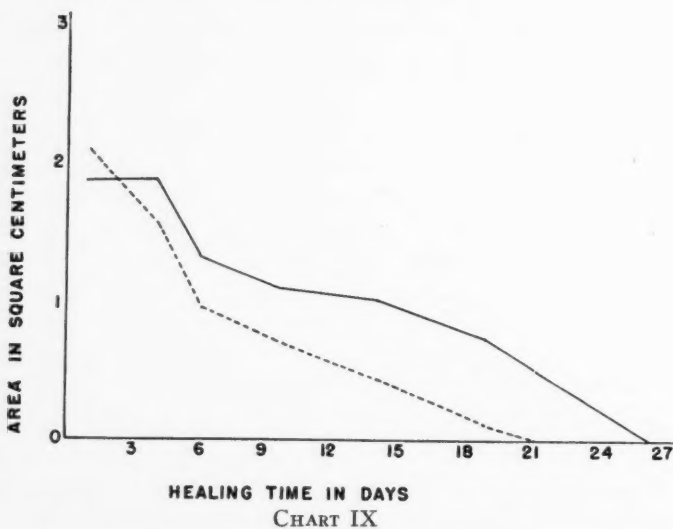
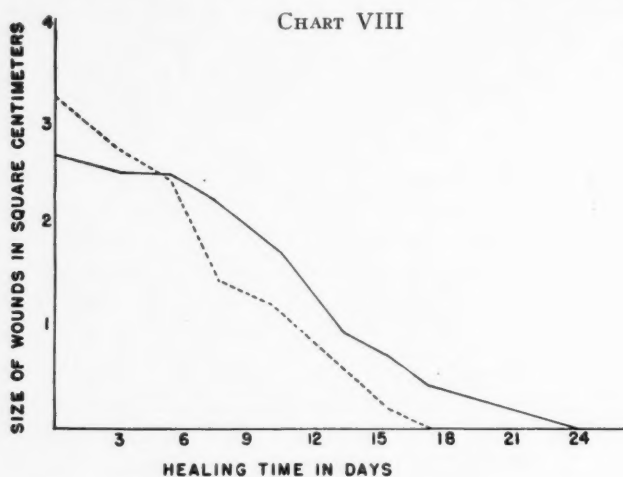


CHART VIII.—(Human Volunteer No. 4): The broken line shows the healing time of the treated wound and the solid line that of the control.

CHART IX.—(Human Volunteer No. 5): The broken line shows the healing time of the treated wound and the solid line that of the control.

that such substances act directly on the metabolic mechanism of cellular proliferation.

Many physical and chemical studies have been carried out by us in an attempt to isolate a presumed factor or factors responsible for the growth-



promoting effect of the total extract. The detailed reports of this work will be published elsewhere, but certain basic experiments warrant comment here. First of all, it should be mentioned that while Fischer,<sup>13</sup> Davidson,<sup>9</sup> and others who carried out extensive studies on the nature of embryonic tissue extracts, and Loofburow,<sup>20</sup> and Cook, *et al.*,<sup>8</sup> working with extracts of injured yeast cells, generally concluded that the active growth-promoting fraction was nucleoprotein; following our own studies we have concluded that this may not be the case.

In order to have a standard supply of material for laboratory and clinical investigation, a method was developed for preparation of extract on a large scale.\* The initial extract was prepared in the manner described from fresh or frozen sheep heart which may have been stored for six months or more in a CO<sub>2</sub> ice box at -70°C. This extract was treated with ether which removed extraneous materials and also cleared-up slight contaminations. Following centrifugation the aqueous fraction, which was even somewhat more active than the original extract, was placed in small containers, frozen and dried *in vacuo*, the containers being sealed under sterile conditions. They contained extract in a powdered form which could be readily dissolved in distilled water. A standard strain of fibroblast cultures was used to test the material resulting from these experiments.

Heart extract is not thermostabile although heating to 60° for 30 minutes has no appreciable effect on activity. Heating-up to 70° C. for 5 to 10 minutes results in a 50% decrease in activity, and when carried out for a prolonged period of time results in a further diminution, but a certain degree of growth-promoting activity is still retained. A temperature of 100° C. does not produce complete inactivation but what remains is probably due to the ordinary nutrient materials which are present even in the heated extract rather than to any specific growth-promoting principle.

The extract is nondialyzable and loses its activity on passing through a Berkefeld filter over a wide range of pH from 3.8 to 8.0, though such changes in pH do not normally effect the growth-promoting activity of the extract. At this pH range about 50% loss in activity is observed in passage through a Seitz filter, but when a small amount of broth is first passed through a Seitz filter it is then possible to filter the extract at its usual pH 6.5 without any appreciable loss in activity.

The activity of the extract remains constant over a wide range of concentrations. Dilution of extract prepared by using one part cardiac muscle and two parts of Tyrode solution (1:2) with as much as four times the volume of Tyrode solution does not affect the activity. Further dilutions of this extract result in a gradual falling-off of activity. However, this extract diluted with 50 volumes of Tyrode solution still manifests some activity. Extracts more concentrated than 1:2 are injurious to cells.

Extracts prepared in the standard way contain about 30 to 130 mg.% of

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\*We wish to extend our appreciation to Lederle Laboratories Inc. for preparation of this extract in bulk.

protein, with a low protein content being usually less active. However, dilution of extract containing 130 mg.% protein with equal quantities of Tyrode solution did not result in a loss of activity; greater dilution of this extract did decrease activity but not in direct proportion to the diminished protein content, nor is the activity of the extract directly related to the general protein content, as may be seen after treatment with dilute hydrochloric acid. Here, lowering of pH from 6.5 to 4.8 causes precipitation, but, following centrifugation and readjustment of pH the supernatant fraction containing 0.5 mg. protein N. per cc. is quite as active as the original which contained 0.85 mg. protein N. per cc. Lowering of pH to 3.6 results in a reduction of protein N. content to 0.3 mg. per cc. without any loss of activity.

Extract was treated according to the method of Sevag, with an equal volume of chloroform and a small amount of octyl alcohol. This mixture was placed in a shaking apparatus overnight and then centrifuged for one hour. The entire procedure was carried out in the cold. Three fractions were obtained. The aqueous and interface fractions did not stimulate cells growing *in vitro*. The residue of the chloroform soluble fraction dissolved in Tyrode solution inhibited cell growth. No evidence was obtained of active nucleoprotein in the aqueous phase. Other proteins present in the interface fraction were denatured. Thus, absence of activity in this fraction does not preclude the possibility of the active factor being protein.

Twenty cubic centimeters of extract were adsorbed with 100 mg. of aluminum hydroxide in one case and with 20 mg. in the other. Both supernatant fractions actively promoted cell growth. The degree of activation was somewhat less than that of the original extract.

When the adult heart extract was centrifuged at 30,000 R.P.M. for 30 minutes, the supernatant fraction was found to be very active in promoting cell growth, while the macromolecular fraction showed only a slight degree of stimulating activity, such as might be due to the presence of nutrient material.

The total adult heart extract as well as the supernatant fraction obtained from ultracentrifugation were irradiated with ultraviolet light (2,640 A.<sup>°</sup>) for various periods of time up to 60 minutes. Following such irradiation, the extract did not lose any of its cell growth-promoting properties. Lyophilized heart extract may be redissolved in distilled water containing 50 mg. of sulfadiazine per 100 cc. without diminishing the activity of the extract or injuring the cells. Penicillin up to 300 Oxford units per cc. may also be added without detracting from the stimulating properties.

In view of recent ideas expressed, that growth stimulation may be produced by globulin, a brief study was made of the effect of the fractions isolated by Cohn, and his group, on cells growing *in vitro*. The gamma globulin fraction stimulates growth of cultures *in vitro* to a slight extent, but the degree of stimulation is much less than that of adult heart extract. Thrombin, also, has a slight stimulating effect, but even less than that of gamma globulin. Finally, fraction IV-I is somewhat more active than thrombin but its effect is not nearly so striking as that seen with adult tissue extract.

From the above data, it may be inferred that the active factor or factors involved in promotion of cell growth while protein in nature are not necessarily nucleoprotein. However, since it has been demonstrated that during cell proliferation or activity there is a large increase in the nucleoprotein content of cells it may well be that we are dealing here with an enzyme which plays a part in nucleoprotein formation.

#### CONCLUSIONS

(1) Experimental and clinical evidence is presented which indicates that there is an active growth-promoting factor present in adult sheep heart extract.

(2) A method is presented whereby adult sheep heart extract may be prepared in large quantities and, thus, be available in stable form for clinical use and experimental study.

(3) This extract appears to exert a markedly stimulating effect on indolent human wounds, and a lesser effect on wounds of normal healthy individuals.

(4) From the experimental data available the active factor would appear to be a protein having many characteristics of an enzyme.

We wish to express our appreciation to Dr. A. Mirsky, of the Rockefeller Institute, for his helpful suggestions, and to Miss I. Jacob for technical assistance.

#### BIBLIOGRAPHY

- <sup>1</sup> Baker, L., and Carrel, A.: *J. Exp. Med.*, **42**, 143, 1925.
- <sup>2</sup> Bergami, G.: *Accad. d. lincei*, **2**, 140, 1925.
- <sup>3</sup> Bogomolets, A. A.: *Am. Rev. Soviet Med.*, **1**, 101, 1943.
- <sup>4</sup> *Bull. War. Med.*, **4**, 251, 1944.
- <sup>5</sup> Carnot, P., and Ferris, E. C.: *rend. Soc. Biol.*, **95**, 655, 1926.
- <sup>6</sup> Carrel, A., and Hartmann, A.: *J. Exp. Med.*, **24**, 429, 1916.
- <sup>7</sup> Caspi, C. S.: *J. Lab. and Clin. Med.*, **29**, 483, 1944.
- <sup>8</sup> Cook, E. S., *et al.*: *Nature, Lond.*, **152**, 474, 1943.
- <sup>9</sup> Davidson, J. N., and Waymouth, C.: *Biochem. J.*, **39**, 188, 1945.
- <sup>10</sup> Doljanski, L., Hoffman, R. S., and Tennenbaum, E.: *Nature, Lond.*, **150**, 23, 1942.
- <sup>11</sup> Doljanski, L., and Hoffman, R. S.: *Nature, Lond.*, **145**, 857, 1940.
- <sup>12</sup> DuNuoy, P. Lecomte: *J. Exp. Med.*, **24**, 451, 1916.
- <sup>13</sup> Fischer, A.: *Actaphysiol. Scand.*, **2**, 1943, 1941.
- <sup>14</sup> Goldberg, D. I.: *Am. Rev. Soviet Med.*, **2**, 225, 1945.
- <sup>15</sup> Greenbaum, F. R.: *Am. J. Surg.*, **14**, 259, 1936.
- <sup>16</sup> Hoffman, R. S., and Doljanski, L.: *Growth, Ithaca*, **3**, 61, 1939.
- <sup>17</sup> Hoffman, R. S., and Dingwall, J. A.: *Surg., Gynec. & Obst.*, **79**, 103, 1944.
- <sup>18</sup> Kerr, A. B., and Werner, H.: *Brit. J. Surg.*, **32**, 281, 1944.
- <sup>19</sup> Kiaer, S.: *Arch. klin. Chir.*, **149**, 146, 1927.
- <sup>20</sup> Loofburow, J. R.: *Biochem. J.*, **36**, 737, 1942.
- <sup>21</sup> Mandl, F., and Maybaum, F.: *Acta Medica Orient.*, **2**, 136, 1943.
- <sup>22</sup> Nakamura, T. C.: *rend Soc. biol.*, **104**, 191, 1930.
- <sup>23</sup> Reinmann, S. P., and Hammett, F. S.: *J. Exp. Med.*, **94**, 1369, 1930.
- <sup>24</sup> Roulet, F. C.: *rend. Soc. biol.*, **95**, 390, 1926.
- <sup>25</sup> Schloss, W.: *Arch. klin. Chir.*, **151**, 701, 1928.
- <sup>26</sup> Schloss, W.: Personal communication, 1942.
- <sup>27</sup> Smith, L. W., and Livingston, A. E.: *Am. J. Surg.*, **67**, 30, 1945.
- <sup>28</sup> Wallich, R. C.: *rend. Soc. Biol.*, **95**, 1480, 1926.
- <sup>29</sup> Waugh, W. Grant: *Brit. Med. J.*, **1**, 249, 1940.
- <sup>30</sup> Young, J. S., Fisher, J. R., and Young, M.: *J. Path. Bact.*, **52**, 225, 1941.

## PRIMARY CLOSURE OF BEDSORES BY PLASTIC SURGERY\*

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IN JUNE, 1944, at the Cushing General Hospital, Major W. B. Scoville began to experiment with the routine early closure of large decubitus ulcerations under the protection of systemic and local penicillin. Impressed by the early results, White, Hudson, and Kennard, in November, 1944, began an investigation of this revolutionary solution of the bedsore problem in sailors and marines with battle injuries of the spinal cord at the U. S. Naval Hospital, in Chelsea, Massachusetts. A report of the first five patients so treated and the impressive results achieved has already been published in the *U. S. Naval Medical Bulletin*.<sup>1</sup> † From this experience it was apparent that systemic penicillin in moderate dosage (120,000 Oxford units injected intramuscularly each 24 hours) effectively prevented sepsis in the widely undermined flaps of gluteal skin and subcutaneous tissue which were used to cover the defect left by the excision of large sacral decubitus ulcers. Provided the plastic closure was carried out with complete freedom from tension and with effective hemostasis, primary healing resulted within two weeks. In the presence of undue tension or with the formation of hematomas minor separations of the flaps occurred. These healed by granulation, contraction of scar tissue, and delayed epithelization within a period of a few weeks. There was no complicating major sepsis. At the time this preliminary report was written the authors felt that the method was safe and capable of producing a great acceleration in the rehabilitation of these seriously injured men. The most effective methods of swinging full-thickness skin flaps to cover sacral lesions had not been worked out and no attempt had been made to close large decubitus ulcers elsewhere, such as are found so frequently in battle casualties after a prolonged period of evacuation from distant outposts, especially in the tropics. As the U. S. Naval Hospital at St. Albans is a Plastic as well as a Neurosurgical Center, we have had a wide choice of material for further development of this valuable method. This report summarizes further experi-

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† In February, 1945, Lamon and Alexander<sup>2</sup> made the first report of the successful closure of such a lesion by these means in a patient in the McCaw General Hospital's Neurosurgical Section, which was then under Major Scoville's charge.



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ence in nine patients with 14 such lesions in various areas over the sacrum, iliac crests, ischial tuberosities, hips, *etc.*

As one of us emphasized in the previous report,<sup>1</sup> decubitus lesions are frequent and serious complications in men who have received transecting injuries of the spinal cord overseas. This is particularly true of sailors and marines who have been sent home through the chain of evacuation hospitals from some remote part of the Pacific after exposure to a tropical climate, inadequate medical and nursing facilities. Under these circumstances bedsores tend to be large and multiple (15 in one marine wounded at Iwo Jima). The sloughs often extend right down to underlying bone, the granulations are avascular and unhealthy in appearance, and all are heavily infected. The tendency of these lesions to enlarge and for new ones to form is due in great part to malnutrition and protein deficiency, with the accompanying anemia and avitaminosis. In some of these unfortunate patients as much as a third of their body-weight may be lost, plasma protein may have fallen below the critical edema level, and the red count below 2.5 million. Protein-rich exudate is lost through the ulcerated areas as rapidly as after extensive severe burns, and all desire to eat and get well disappears. As with the victims of the German concentration camps, the first problem is to correct the nutritional deficiency and restore the individual's will to live. This preliminary period requires expert and unremitting nursing care plus constant effort to attain a satisfactory intake of calories and protein, as well as to administer adequate amounts of whole blood, iron, and vitamins. All possible sources of infection must be eliminated by the surgeon, and the urologist must attend to the difficult problems of tidal drainage, prevention of urinary sepsis, and stone formation. Much can be contributed by the Red Cross worker, chaplain, and psychiatrist in helping the patient regain his social and mental readjustment. Furthermore, war-time experience at Navy and Army hospitals has shown the value of physical exercise, which should be started in bed at the earliest possible moment. Once the nutritional deficiency has been corrected and the individual restored to a better all-around physical and mental state, the granulation tissue develops a healthier color and renewed growth, the sloughs tend to separate, and the skin edges to sprout-out new epithelium. This is the time for the radical plastic closure of these lesions, and it can usually be reached in a period of from one to two months' hospitalization, unless there are other complicating conditions. On the other hand, if standard conservative treatment is employed, even under most favorable circumstances healing will require many months (Guttmann<sup>3</sup>). When the thin layer of newly formed epithelium has ultimately covered the avascular bed of scar, it is liable to break down again and again as the individual begins to sit up and attempts to walk with braces. The same is true when these areas have been more rapidly covered by thin split-thickness grafts (White, Hudson, and Kennard<sup>4</sup>). We are now thoroughly convinced that, once the fundamental state of malnutrition has been corrected and recurrent sepsis from the urinary tract and other



wounds has been eliminated, the most effective solution of this problem is excision of the ulcerated areas and plastic closure by sliding in flaps of normal subcutaneous tissue and skin under the antibacterial protection of penicillin. The same is undoubtedly true of decubitus ulcers in civilian patients, although with proper nursing and better nutrition from the outset lesions of this type should rarely develop.

#### SURGICAL TECHNIC

Plastic closure of bedsores can be undertaken as soon as the patient's general condition has reached the satisfactory status outlined above. He must also have accustomed himself to lying permanently in a prone or slightly lateral position. For several days before the patient is taken to the operating room, it has been our practice to make sure that the lower bowel is thoroughly evacuated by manual removal of fecaliths and colonic irrigations. In preparation for the operation the patient is given 30,000 units of penicillin intramuscularly and sedation with a barbiturate and morphine. No anesthesia is ordinarily needed. The scarred, infected edges of the ulcer are first trimmed with a safe margin, together with the superficial layer of granulations over its entire base. When, as is sometimes the case, there is undermining, the granulations under the flap should also be excised. Avascular areas where sloughs are adherent must be cut-back to a fresh vascular base. In one case (Patient 3, Figs. 1 and 2) we were forced to remove the coccyx and to rongeur away a portion of the lower sacrum on account of the presence of osteomyelitis.

Although preliminary cultures were always taken and the bacterial growth heavy, we have not found it necessary to pay any special attention to the type or number of micro-organisms, provided the flaps are sutured without tension and maintain an adequate circulation. However, in Patient 7, where mild infection developed secondarily to partial separation of the flaps, streptomycin might have been of help in cleaning-up the low grade colon bacillus infection in the necrotic edges of the flaps and permitting an earlier secondary closure (Fig. 3). The use of this drug might also have helped clear up the single instance of more severe infection with *B. proteus* and anaerobic *Streptococcus* which developed after closure of the second decubitus ulcer in Patient 5 and resulted in the only failure in this series. Unfortunately, streptomycin was unobtainable at that time. Sulfasuxidine, if given for a period before and after these plastic procedures close to the anus, might also prove helpful by reducing the number and virulence of the fecal bacteria.\*

All of the patients in this group of cases had lost weight, many to a rather alarming degree, and all showed marked muscular atrophy. The skin below the cord lesion thus became quite loose and flabby, a fact that actually facilitated the closure and often made it possible to cover the smaller ulcers merely by

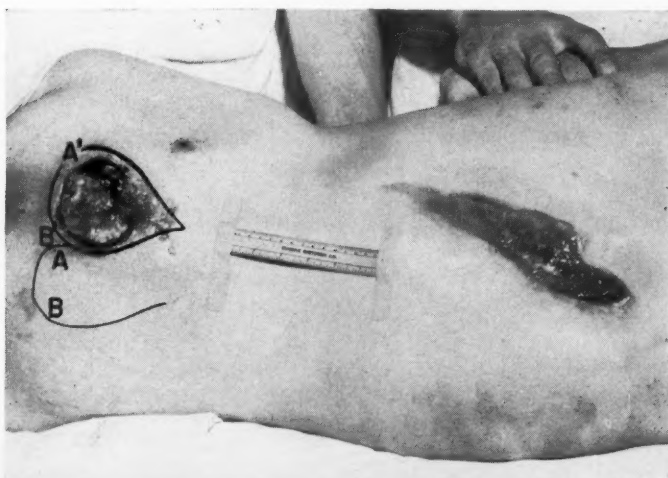
\* We are indebted to Dr. Oliver Cope, of the Massachusetts General Hospital, Boston, for this useful suggestion, but have not yet had the opportunity to put it to the test.

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undermining in all directions and drawing the skin margins together with sutures, as in the dorsal decubitus ulcer illustrated in Figures 1 and 2A.

One of the fundamentals of plastic surgery is accurate approximation of

A



B

FIG. 1.—Case 3: (A) Preoperative photograph of patient's back showing lower dorsal and sacral decubitus ulcers. The area of excision of the sacral ulcer and the outline of the plastic flap are marked. It was necessary to remove the coccyx and to rongeur away the lower sacrum for osteomyelitis.

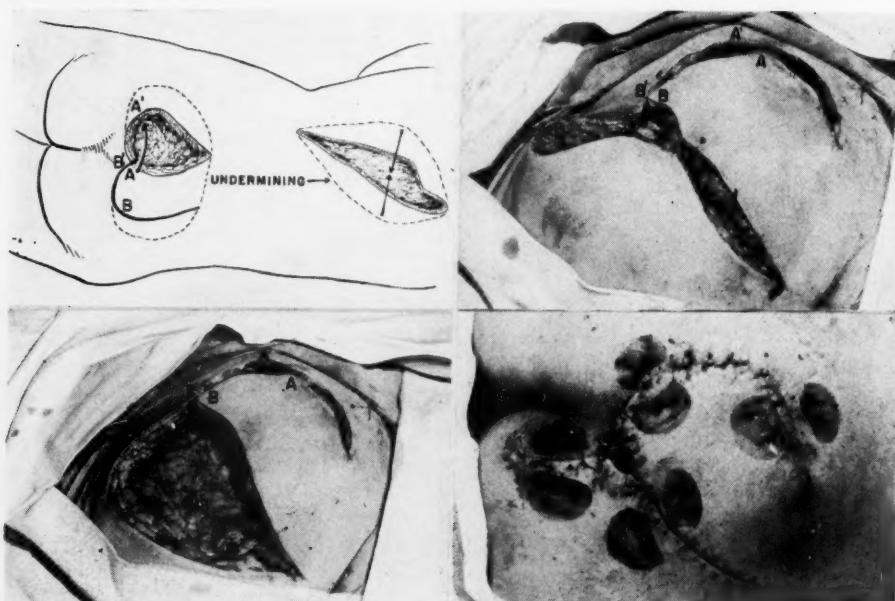
(B) Photograph taken three months later. The recent midline low thoracic incision through the area of plastic repair was made two weeks previously for laminectomy and exploration of the spinal injury.

skin margins without undue tension, and unless this rule is adhered to strictly the results are apt to be disappointing. In cases where it was felt that simple undermining and suture resulted in too much tension, one or more skin flaps

were outlined and switched over the ulcer, and the bed of the flap closed by drawing the skin edges together, after mobilizing by undermining (Figs. 2, 3, 4). The flaps must be planned very carefully and accurate measurements made before being raised. The pedicles of the flaps should, if possible, always

FIG. 2-A

2-C



2-B

2-D

FIG. 2.—Case 3, continued: (A) Diagrams of areas undermined and the sacral flap raised.

(B) Photograph of sacral area on rotating the flap. Point A in diagram is slid to A', B to B'.

(C) The defect left after rotating the flap has been closed by subcutaneous suture with No. 00 plain catgut.

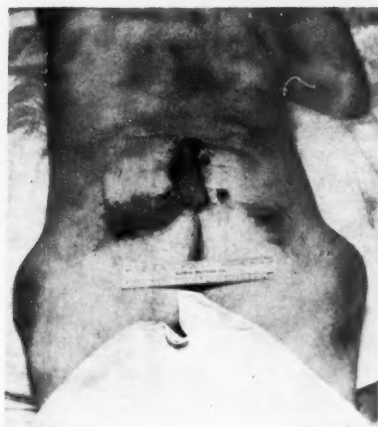
(D) The first dressing a week later: Part of the silk cutaneous sutures have been removed. The mattress stitches of stainless steel are shown with the buttons of roentgen ray film. These will be left in position for another week. There is a 1-cm. area of separation at the angle which was not undermined and which healed without any visible infection.

be in line with the direction of the arterial supply. Where possible, they should be raised in conformity with the natural lines of skin tension. The latter is of less importance than the former, since the end-result we are working for is closure of the ulcer rather than a good cosmetic appearance. In none of the cases in this series have we resorted to using the delayed-flap method, although probably this would have been a help in one case (Patient 7, Fig. 3). We feel sure that by delaying the flap—in other words, raising it in stages and not trying to complete the operation in one stage—we could close larger defects than those shown. It is our intention to do this in selected cases in the future. In planning the flaps we have not attempted to utilize any mathematic formula

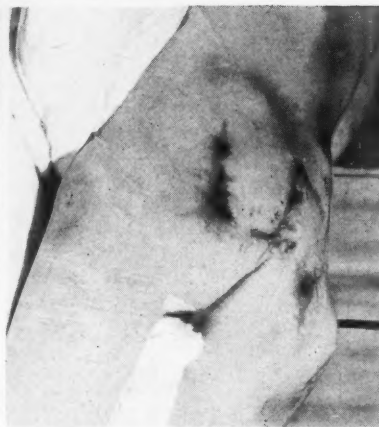
## PRIMARY CLOSURE OF BEDSORES

as regards the surface area in relation to the size of the pedicle, but have relied on the color of the flap and the presence of active bleeding at its tip as evidence of sufficient blood supply. It goes without saying that the flap should be adjacent to the ulcer, and for midline ulcers over the sacrum and coccyx the best donor area is the buttocks. The base is placed above and the tip may

A



B



C

FIG. 3.—Case 7: (A) Outline of large double flaps with necrosis of edges, as seen at time of first dressing.

(B) Appearance of flaps one month later, prior to secondary plastic.

(C) Photograph showing healing two and one-half months after primary operation.

extend to the subgluteal fold (Fig. 2). In large ulcers it may be necessary to use two flaps, one from each buttock, with the base of the flap placed higher on one side than the other (Fig. 3). As a general rule, it is wise to try to avoid having the flaps meet in the midline, although it is not always possible to avoid this and it does not invariably lead to an unsatisfactory result.

TABLE I

Patient	Site and Size	Culture	Operation	Postoperative Course	Time of Healing
1. Charles F. Lt. USNR	Sacral: 3 x 6 cm.	<i>Hemolytic Streptococci</i>	Sliding flap 6/15/45	Small hematoma leaving 2 x 3-cm. opening, which drew together after granulation	3 mos.
2. William W. BM 2/c	1. Sacral: 4 x 6 cm.	<i>B. coli</i> and <i>Staph. aureus</i>	Sliding flap 7/16/45	Primary healing, but partial re-opening 5 wks. later, following urinary sepsis	Immediate
	2. R. hip: 3 cm.		Simple closure 9/26/45	Primary healing	Immediate
3. Alan W. AMM 3/c	1. Sacral: 8 cm.	<i>B. pyocyaneus</i> and <i>B. coli</i>	Sliding flap 7/20/45	Primary healing except for 2-cm. area of suture separation	1 mo.
	2. Midback: 8 x 19 cm.		Simple closure 8/28/45	Primary healing	Immediate
4. Walter M. Pvt.	1. Sacral: 5 cm.	<i>B. coli</i>	Simple closure 9/6/45	Primary healing	Immediate
	2. Hip: 6 x 9 cm.	<i>Anaerobic Streptococci</i>	Sliding flap 10/15/45	Primary healing except for 2 x 3-cm. separation which required secondary suture	3 mos.
	3. Post. sup. spine: 5 cm.		Simple closure 1/16/46	Primary healing	Immediate
5. John C. Lt. USMCR	1. L. hip: 5 x 8 cm.	<i>B. proteus</i> , <i>B. coli</i> , <i>hemo-lytic Staph. albus</i> and <i>anaerobic Strep.</i>	Sliding flap 10/5/45	Primary healing, but recurrence after second operation	Immediate
	2. R. hip: 3 x 5 cm.		Simple closure 1/4/46	Acute infection and ultimate separation of flaps	Failure
6. George A. Pvt.	Sacral: 3 x 4 cm.	<i>Staph. albus</i>	Simple closure 10/22/45	Small central separation of incision, which healed by granulation and contraction	5 wks.
7. Lionel LaF. Pvt.	Sacral: 12 cm.	<i>Staph. aureus</i> and <i>B. coli</i>	Bilateral sliding flaps 10/24/45 Secondary closure 11/30/45	Partial necrosis and separation of flaps Successful approximation, with delayed healing	2.5 mos.
8. James S. S 1/c	Ischial tuberosity: 4 cm.	<i>B. coli</i> and <i>anaerobic Strep.</i>	Simple closure 11/26/45	Slight separation and delayed healing of central third of flap due to hematoma. Small secondary breakdown after sitting on unpadded seat	2 wks.
9. Theodore K. S 2/c	Post sup. spine: 3 cm.	<i>Hemolytic Strep.</i> and <i>B. proteus</i>	Simple closure 1/11/46	Separation of central third of incision because of hematoma	Firm healing in 2 wks.

The best donor site for flaps to cover ulcers over the anterior superior spine is the skin just lateral to the spine on the side of the thigh, and to cover ulcers over the greater trochanter we have slid a flap from the lateral surface of the buttock (Fig. 5). Ulcers in these regions are often relatively small and the closure of the donor site is then a simple matter.

Absolute hemostasis and the avoidance of hematoma formation is essential to primary healing, and the greatest of care is required to accomplish this. A hematoma will always prevent primary union (Fig. 4) and the time taken to obtain hemostasis is well spent. The liberal application of fibrin foam soaked in thrombin to any points which show a tendency to ooze should help prevent this complication.



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We have used No. 00 plain catgut sutures for the subcutaneous tissue and silk for the skin. The suture lines are reinforced by sutures of fine stainless steel wire in mattress fashion, tied over small disks of roentgen-ray film to prevent cutting into the skin (Fig. 2D and 3A). The dressing is composed of several layers of gauze, over which mechanic's cotton waste is placed and the entire dressing held firmly in place by elastic adhesive strapping for firm, even pressure.

After operation the patient with a plastic repair over the sacrum is kept on his face or side to keep the weight of his body off the flap and he is not permitted to lie on his back for 14 days. Penicillin is given intramuscularly in doses of 15,000 Oxford units at three-hour intervals over this period. In order to prevent early soiling of the surgical dressing after plastic closure of decubitus ulcers in the region of the buttocks, the patient should be fed a low residue-constipating diet and liberal doses of paregoric for the first week, followed by an enema just before the first postoperative dressing. This is normally done on the 6th to 7th day and most of the skin sutures are removed at that time (Fig. 2D). The wire tension sutures are removed on the 12th or 14th day. If there is evidence of hematoma formation, the clot is evacuated and the cavity packed with gauze soaked in a solution of penicillin. Secondary suture to obliterate the cavity may be undertaken later if deemed necessary (Fig. 3B and C).

### RESULTS

The results of this method of radical one-stage excision and closure of various types of decubitus lesions in paraplegic patients are set forth in Table I and the accompanying photographs. Study of these data shows that primary healing took place after six of the 14 operations (Patients 2, 3, 4, 5; Figs. 1 and 6). Following six other operations (Patients 1, 3, 4, 6, 8, 9) there was primary healing of nearly the entire area, but a small portion of the cutaneous flaps, 1 to 2 cm. in extent, separated because of undue tension or an underlying hematoma (Figs. 2D and 4). Although this area remained free of visible infection in each instance, it required from a few weeks up to three months to heal by granulation and secondary ingrowth of epithelium. After the closure of the large trochanteric decubitus ulcer in Patient 4 (Fig. 5), it was necessary to close a residual 2-cm. superficial defect by a secondary plastic procedure. Even in these instances most of the patients were able to be up in a wheel chair within two weeks and the final result left little to be desired, as the area of the former lesion was covered with full-thickness, freely movable skin, with an underlying pad of fat.

Troublesome postoperative complications resulted in only two patients. A single instance of major postoperative sepsis occurred in Patient 5. Here, a 5 by 8-cm. decubitus ulcer over the left great trochanter had been previously excised and successfully healed by primary union. Following this the patient's general condition had deteriorated, due to an adhesive peritonitis, partial intestinal obstruction, and severe malnutrition. In addition to a huge sacral

bedsore, there were decubitus ulcers over both ischial tuberosities and a 3 by 5-cm. lesion over the great trochanter on the right side. On account of a complicating compound fracture of his humerus, it was impossible to make this patient lie in the prone position. We resolved to attempt to close the bedsore over the right hip, in spite of his obvious malnutrition, in the hope that he would then be able to spend more time in the lateral position and thereby take the weight off his sacrum and buttocks. This ulcerated area was excised and the edges drawn together on January 4, 1946. Four days later



FIG. 4.—Case 1: (A) Preoperative photograph of sacral bedsore, with outline of extent of excision and area in left buttock to be raised for sliding flap.

(B) Photograph taken two weeks later showing first intention union of all but small undermined area at site of hematoma.

(C) Photograph taken three months later. There is a thick pad of fat and the skin is not adherent to the sacrum.

there was a fever of  $101.8^{\circ}\text{F.}$ , and the skin flaps were found to be undermined with pus, which contained *anaerobic Streptococci* and *B. proteus*. A few sutures were removed and the cavity irrigated at three-hourly intervals with penicillin solution (1,000 units per cubic centimeter), in addition to the routine intramuscular injection. His temperature returned to normal within 24 hours, but there was subsequent complete separation of the flap and failure to reduce the extent of the ulcerated area. Unfortunately, we were unable to obtain any streptomycin at this time.

The other postoperative complication, which occurred in Patient 7, was caused by undue tension and inadequate circulation of the transposed cutaneous flaps. Here, it was necessary to remove a large area of avascular scar surmounted by three indolent ulcers. This measured 12 cm. in diameter and covered most of the sacrum. To close such a large area it was necessary to

# PRIMARY CLOSURE OF BEDSORES

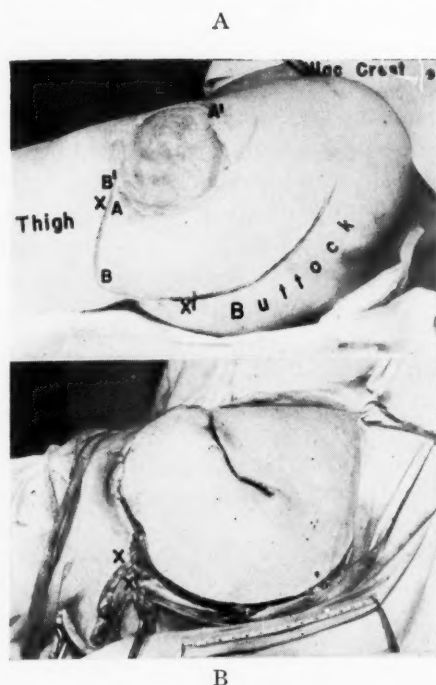


FIG. 5.—Case 4: (A) Photograph of 6 x 9-cm. trochanteric decubitus ulcer, with outline of flap to be raised. After excision of the ulcer and its scarred edges point A is to be rotated to A', B to B'. The resultant defect at the lower left-hand corner will be closed by undermining the thigh and buttock and approximating X to X'.

(B) The flap has been rotated and area from which it was taken closed by subcutaneous suture with No. 00 plain catgut. Silk cutaneous and wire mattress stitches remain to be placed. Tension on skin edges was minimal, but there was a small separation in lower limb near the anus which required secondary closure.

plastic flaps appear to be just as resistant to pressure necrosis as other areas of intact skin, the facility with which insensitive skin can break down must always be borne in mind. Two of the five patients reported by White, Hudson, and Kennard<sup>1</sup> developed small secondary decubitus ulcers in the transposed flaps when they were forced to return to bed and lie on their backs because of late urinary sepsis. This unfortunate complication has occurred in Patients 2, 5, and 8 of the present series. In the first, the primary sacral closure had healed by first intention (Fig. 6), but 5 weeks later a severe ascending urinary infection, accompanied by a fever of 105°F. caused the distal 3 cm. of the transposed flap to break down and a new 3-cm. ulcer to form overnight over the right great trochanter. This was subsequently closed and healed *per primam*, but at eight months a 2 by 4-cm. superficial defect still remains over the

elevate and swing in bilateral flaps. The edges of these appeared slightly blanched as the postoperative dressing was applied. Within a week there was definite necrosis of the distal 2 to 3 cm. of both flaps (Fig. 3A), which gradually sloughed away. Although cultures from the sloughing areas showed a heavy growth of *Staphylococci*, *anaerobic Streptococci*, and *B. proteus*, there was no tendency for infection to spread into the widely undercut areas and almost no evidence of systemic absorption. Within a month the necrotic tissue had been absorbed (Fig. 3B) and it was possible to reapproximate the 3 to 4-cm. gaps by a secondary plastic operation. This time healing was satisfactory, and at the end of a month the sacrum was covered with a fair cushion of full-thickness skin and subcutaneous fat (Fig. 3C). If confronted by a similar situation in the future, where there is even a slight blanching of the flaps, we plan to resort to the "delayed-flap" method and complete the plastic at a second stage.

After the successful closure of decubitus lesions there is still the possibility that secondary ulceration may take place. Although well prepared

sacrum (approximately a third of the area of the original flap). The second case of recurrent ulceration occurred in Patient 5, mentioned above. Here, in desperation, we attempted to close a trochanteric ulcer in a severely undernourished patient because this unfortunate officer was unable to lie prone and had steadily increasing decubitus ulcers over his sacrum and both buttocks. If this 3 by 5-cm. ulcer could have been closed he would have been able to spend a large part of the time lying on either side. This ill-advised attempt on our part resulted not only in acute infection and breaking down of this plastic, as already stated above, but also in a partial breakdown of the beautifully healed area over the opposite hip, which had united *per primam* after an earlier closure. The third case of recurrent ulceration was only a partial breakdown of a successfully closed decubitus ulcer over the ischial tuberosity. This patient had been taken to a hockey game and sat for several hours on a poorly cushioned seat.

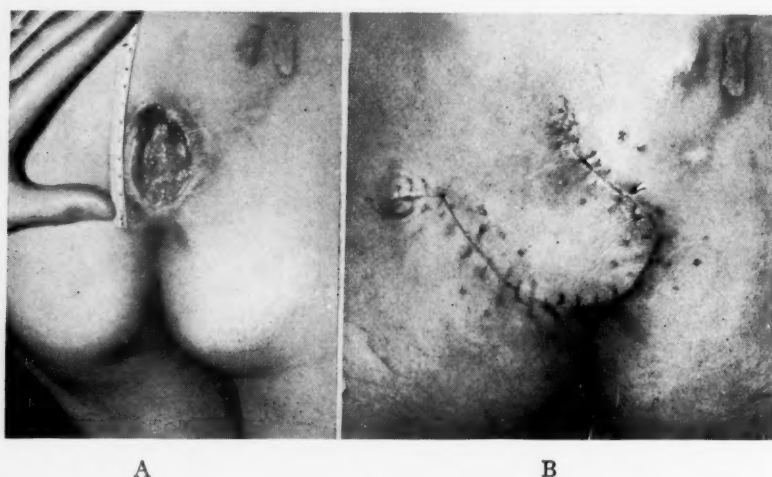


FIG. 6.—Case 2: (A) Preoperative photograph of the sacral decubitus ulcer. (B) Primary union at end of two weeks.

The lesson to be derived from the first two discouraging instances of secondary ulceration after successful plastic closures is that the procedure should be undertaken only in reasonably well-nourished individuals who are past the stage of recurrent episodes of sepsis, either from the urinary tract or from other wounds. This state is far easier to attain in civilians, who never should become severely undernourished and in whom complications outside the urinary tract are relatively infrequent. Out of a group of 30 war-time paraplegic patients, five remain to date with decubitus ulcers which we have been unable to attempt to close. Three of these marines, on admission, were so undernourished and had so many and such large bedsores that it has been impossible to build them up to a state of positive nitrogen balance. In two others, persistent sepsis from other wounds has prevented reparative plastic



surgery to date. One of these men had a chronic empyema following a crushing injury to his chest and spine, the other a traumatic fecal fistula, osteomyelitis of the ilium, and retroperitoneal abscess. Both of these men are well on the road to recovery from their septic foci, and nearly ready for closure of their indolent pressure sores.

#### SUMMARY AND CONCLUSIONS

1. With the protection of penicillin, decubitus ulcers can be resected and closed by primary suture. This permits rapid closure with full-thickness skin and early rehabilitation of patients with spinal paraplegia.

2. Adequate preliminary treatment is essential to combat anemia, hypoproteinemia, and avitaminosis. Bladder paralysis is treated by tidal irrigation; chemotherapy and surgical measures are used to clear-up sepsis in the urinary tract and the tissues surrounding the decubitus ulcer.

3. The ulcer is then débrided and plastic skin flaps swung in for primary closure. A compressive dressing is applied and penicillin is given intramuscularly during the healing period.

4. Surgical technic and end-results after closing 14 of these ulcers are described.

5. Experience proves that clean healing is the rule. Hematomas or undue tension result in small defects which heal cleanly but more slowly. Within 14 days many of these lesions have been firmly healed with well-padded movable skin covering the former defect. Troublesome postoperative complications have resulted in only two cases—necrosis and separation of the cutaneous flaps resulting from undue tension, and a single instance of frank sepsis in a malnourished patient.

6. Even after a pressure sore has been excised and successfully covered with full-thickness skin and subcutaneous tissue, it can break down again during periods of inadequate care or severe infection.

#### REFERENCES

- <sup>1</sup> White, James C., Hudson, Henry W., Jr., and Kennard, Harrison E.: Treatment of Bedsores by Total Excision with Plastic Closure. U. S. Nav. Med. Bull., 45, 454-463, September, 1945.
- <sup>2</sup> Lamon, J. D., Jr., and Alexander, E., Jr.: Secondary Closure of Decubitus Ulcers with Aid of Penicillin. J. Am. Med. Assoc., 127, 396, February 17, 1945.
- <sup>3</sup> Guttman, Ludwig: New Hope for Spinal Cord Sufferers. Medical Times, 73, 318-326, November, 1945.

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## THE PRIMARY CLOSURE OF DECUBITUS ULCERS\*

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BEDSORES are caused by the interruption of the blood supply to the skin by pressure. Necrosis occurs when this local anemia is continuous and persists for a sufficient length of time. Very little quantitative data can be found in the literature upon the amount of pressure required to produce complete anemia of the skin and the duration of the anemia required to produce necrosis. The War Department Technical Bulletin (TB MED 162) on the care of patients with spinal cord injuries reads: "It is believed that maintained pressure for three to four hours may be sufficient to produce skin necrosis." The evidence for this statement is presumably based upon clinical observation.

Trumble,<sup>25</sup> in 1930, made an attempt to obtain quantitative data on the duration and amount of pressure which could be tolerated by normal skin. He studied skin tolerance for pressure and pressure sores, pointing out that the duration and amount of pressure are the important factors in the production of decubitus ulcers. He conjectured that skin tolerance for prolonged continuous pressure was probably well below 120 mm. Hg., or 2.3 lbs. per square inch. The problem was studied by applying a small rubber bag to the dorsum of the foot in two subjects, one a boy 12 years old and one a man. Constriction was avoided by bandaging over a plaster slab applied to the sole of the foot. The rubber bag was connected by a tube to a funnel of water which could be raised and lowered. He found that the boy could tolerate a pressure of 39 inches of water, or 73 mm. Hg., for days without experiencing pain. This amounts to a pressure of about 1.5 lbs. per square inch. The pressure the man could tolerate was slightly lower, about 1.25 lbs. per square inch. No further details concerning these observations are given. They obviously require confirmation and elaboration.

The surface area of a man five feet eight inches tall, weighing 150 lbs. is about 2,790 square inches. Trumble<sup>25</sup> points out that if only one-fifth of this area were available for weight-bearing in the recumbent position and the pressure were evenly distributed, it would amount to less than one-third of a pound per square inch. However, the weight of the body in reality falls heavily on certain points the combined areas of which are very small. These

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\* Report based on experience with paraplegic patients in an Army General Hospital in the United States.

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points occur over parts where the skeleton is near the skin surface, *i.e.*, the heels, the sacrum, the posterior superior iliac spines, the spines of the vertebrae and the scapulae, *etc.* The skin in these regions bears the weight not only of the part directly above it but also of other parts which are not adequately supported. The bulky soft parts, the buttocks and calves, deform with pressure and evade the responsibility of carrying the weight of the tissues directly above them.

The evaluation of the neurogenic trophic factor in decubitus ulcers of paralyzed patients has plagued the literature since the time of Charcot,<sup>4</sup> despite the fact that a number of his eminent contemporaries disagreed with him. Brown-Sequard,<sup>3</sup> in 1853, published some classic observations bearing on this question: "On guinea-pigs, upon which the spinal cord was cut in the dorsal region, and on pigeons, upon which the spinal cord was destroyed from the fifth costal vertebra to its termination, I have found that no ulceration appeared when I took care to prevent any part of their bodies from being in a continued state of compression, and of washing them many times a day to remove the urine and feces. In cases where an ulceration had been produced, I have succeeded in curing it by washing and preventing compression. I have found that in animals having the spinal cord cut across every kind of wounds or burns were cured as quickly as in healthy animals. Therefore, the ulcerations which appear in cases of paraplegia do not exist directly in consequence of the palsy; they can be avoided and in many cases they can be cured."

Sir James Paget,<sup>22</sup> writing at the same time as Charcot, was well aware of the essential cause of bedsores: "Bedsores may be defined as the sloughing and mortification or death of a part produced by pressure . . . In bedsores the pressure is continual, the blood is driven away, nourishment ceases, and death of the part takes place. . . . If there is the slightest movement from one side to the other, bedsores may be averted . . . In case of those whose lower limbs may be paralyzed, there can be no motion whatever, and so they are liable to bedsores." In 1889, Cohnheim<sup>5</sup> in discussing the subject of bedsores, succinctly disposed of the question of trophic nerves in the following manner: "After all that has been said, you will grant, I think, that the evidence brought forward up to the present is too imperfect to admit of our inferring therefrom either the existence of trophic nerves or the importance of trophic nervous influence for the nutrition of the organs and tissues in general."

Despite the evidence of these authorities, Charcot's influence persisted. Freeman,<sup>12</sup> in 1907, writing in Keen's System of Surgery, remarked that Charcot attempted to explain the rapid spread of decubitus ulcers associated with spinal cord injuries by assuming the "existence of certain trophic centers governing nutrition, damage to which results in 'neurotic necrosis' when aided by local pressure." However, he further states that: "In considering the causation of bedsores, it is customary to keep prominently in view their division into ordinary decubitus and that appearing in connection with nervous lesions, although it is doubtful if any real difference exists between them."

Munro<sup>21</sup> is the most recent proponent of the importance of nervous in-

fluences in decubitus ulcers of paralyzed patients. He believes that "an adequate supply of blood to the skin depends on the integrity of two reflex arcs, which must include at least the spinal cord." He states that bedsores which exist in connection with spinal cord injuries start as pressure sores "but develop more viciously and more widely because of the deleterious effect of spinal shock on the local cutaneous vascular reflexes." The clinical evidence in support of this explanation is based on comparing the incidence of bedsores and the hospital mortality in patients with thoracolumbar cord injuries and in those with cervical cord and cauda equina injuries. The conclusions drawn from this evidence do not appear to us to be warranted.

Local pressure on the skin and the influence of malnutrition afford an adequate explanation for the appearance and rapid spread of decubitus ulcers in paralyzed patients without invoking an hypothetical factor of nervous reflexes or neurogenic trophic disturbances. Pressure on the skin of the paralyzed patient is apt to be more continuous because, awake or asleep, he does not change his position frequently as does a normal individual. Furthermore, because of the absence of pain sensations from the skin which has been pressed upon, the normal stimulus to such movement does not exist. We do not believe that any neurogenic trophic changes occur in the anesthetic skin of patients with paraplegia. The only obvious change in the skin is the dryness due to the usual, but not invariable, absence of sympathetic activity.

Reactive hyperemia is the most important protective mechanism in the body to prevent skin necrosis following a period of anemia. The reaction has long been known<sup>17</sup> but the most comprehensive and authoritative work on the subject has been done by Sir Thomas Lewis.<sup>16</sup> Cope<sup>6</sup> has emphasized the importance of this reaction in relation to bedsores.

We shall discuss here the phenomenon only in relation to the skin. The reaction consists of a flushing with blood of skin previously deprived of its blood supply. Absence of the blood supply for five seconds will produce a perceptible reaction. The duration of the flush is related directly to the length of the interruption of the blood flow, up to a period of an hour or more. Roughly, the reaction lasts one-half to three-quarters of the time of vascular occlusion, and "is thought to result from the accumulation in the extravascular tissue fluids of slowly diffusible substances, the products of metabolism during the period of circulatory disturbance."<sup>16</sup> Lewis has conclusively shown that the reaction is a local one and is independent of both the central nervous system and local reflexes.

Thus, the most important feature of the prophylactic and active treatment of decubitus ulcers must be the avoidance of prolonged periods of pressure upon the skin, pressure which is sufficient to produce local anemia. The simplest method of accomplishing this is to turn the patient every two hours. When a number of paraplegic patients are being cared for, this requires the constant vigilance of a large staff of nurses, orderlies and assistants. The few decubitus ulcers which developed while patients were under

our supervision always followed blanching pressure upon an area of skin for longer than two hours.

There is another way of attacking the problem. Trumble<sup>25</sup> has pointed out that there are two quite different methods of distributing the weight of the body so as to avoid excessive pressure on the areas of skin overlying bone. One is by providing a very soft bed and the other is by employing a very hard one. A prototype of the first is the "water-bed," which consists of a rubber bag mattress partially full of water which allows the body to sink into it and so requires the bulky soft parts to support their share of the weight of the body. There are many variations of this type of bed, such as the air mattress, the foam rubber mattress<sup>23</sup> and the sawdust bed.<sup>13</sup> The hard bed also equalizes pressure by an entirely different method. It consists of an accurately fitted plaster of paris shell. For a patient recumbent in the supine position the plaster shell extends from the gluteal folds and may or may not include the neck and head above. Laterally, it extends half way around the body on either side. A patient may lie in such a plaster shell for months,<sup>6</sup> without changing position and the skin will remain intact and healthy. In making such a plaster shell Trumble emphasizes the importance of placing one-quarter-inch wool pads over the bony prominences. These wool pads are later removed. The plaster shell is made with the patient in the prone position and in this position the soft parts sag away from the bony prominences of the back. The placing of the pads in making the plaster shell compensates for this when the patient is turned to the supine position.

One or another of the above methods, *i.e.*, frequent change of position, a soft bed which distributes the weight of the body over a large area of skin, or a hard bed which conforms to the contours of the body, and so accomplishes the same thing, must always be employed in handling the paralyzed patient.

The state of nutrition of the patient is a factor of great importance in the treatment of decubitus ulcers. Adequate supplies of protein<sup>24</sup> and vitamins<sup>15, 19</sup> have been shown to be essential to wound healing in recent years. Freeman,<sup>12</sup> as early as 1907, observed that in rare instances of severe malnutrition, areas of skin necrosis may appear where the pressure upon the skin "is slight or transient, such as is produced by the mere weight of the bed clothes or the hand lying upon the abdomen. In cases of extreme emaciation certain bones, particularly the anterior superior spinous processes of the ilium, may protrude through the overstretched and atrophic skin without the aid of external pressure at all." Such instances are, of course, extreme but serve to emphasize the nutritional factor in the production of decubitus ulcers. Recently Mulholland, *et al.*<sup>20</sup> found that in 35 random cases of bed-sores the plasma protein concentration in all of them was below 6.4 Gm. per cent. Healing or marked improvement in the ulcers occurred in eight patients who were given a high protein diet. Thus, it becomes of the utmost importance to insure that these patients receive a high protein diet and adequate supplies of vitamins.



With a good general state of nutrition and the avoidance of local pressure, small superficial decubitus ulcers will eventually heal. Often the process requires months during which time there is a continuous loss of protein-containing fluid from the granulating surface which further complicates the nutritional problem. Large ulcers and those with deep pockets often fail to heal even after months of the best conservative therapy. The similarity of the problem to that following a burn with full-thickness skin loss is obvious. The early employment of skin grafting very naturally suggests itself as a simple and adequate method of promoting healing of these ulcers. Consequently, in many Army hospitals in this country skin grafting represented the first surgical attack upon decubitus ulcers. Small deep<sup>10</sup> and split-thickness<sup>2</sup> skin grafts were the types which we employed. We were generally successful with small deep grafts, and believe they are of definite value in the surgical treatment of these ulcers. However, we, and others, have not been satisfied with the results of either spontaneous healing or free skin grafts for the following reasons:

The end-result of spontaneous healing is a dense scar overlying a bony prominence, covered with a thin sheet of squamous epithelium adherent to the underlying scar. This area is liable to break down from slight pressure, and obviously such a patient is far more likely to have a recurrent decubitus ulcer than a patient with full-thickness skin and subcutaneous fat overlying a bony pressure point. The same criticism applies to the results of skin grafting. An avascular scar is still present, there is no subcutaneous tissue, and the skin is not full-thickness.

It was with these points in mind that a decision was made to cover the bony pressure points with subcutaneous fat and full-thickness skin by excising the ulcer and closing the defect by rotating and advancing skin flaps from the immediate vicinity of the ulcer. The advantages of using adjacent skin in preference to skin flaps or tubes from a distant site are several. The closure is immediate, it is done in one stage, and does not require the use of plaster to immobilize the parts while the flap or tube is becoming vascularized at its transplanted site. All these considerations are important in patients with paraplegia.

We have been unable to discover in the literature prior to 1945 any reports on the excision and primary closure of decubitus ulcers. During 1945 a few surgeons in Army hospitals in the zone of the interior have reported at Service Command Conferences small series of cases in which bedsores were treated by skin grafting or some form of plastic closure. In February, 1945, Lamon and Alexander<sup>14</sup> reported the successful excision and primary closure of three decubitus ulcers in one patient. The ulcers were apparently small and were excised by an elliptical incision and a linear closure was performed after undermining the skin. In January, 1946, Croce, Schullinger and Shearer<sup>9</sup> reported their results in eight sacral decubitus ulcers treated by excision and primary closure. Their procedure is fundamentally similar to the procedure we have employed—excision of the ulcer and surrounding



## CLOSURE OF DECUBITUS ULCERS

scar in one piece, the development of adjacent skin flaps and primary closure. The only essential difference between their technic and ours is that we have usually employed only two broad flaps and have avoided angles. Closure has been achieved by rotating these broad flaps rather than by advancement of multiple small flaps.

The principles which most of us have employed were well illustrated and discussed by Davis<sup>11</sup> in 1938, in an article on the "Operative Treatment of Scars following Bedsores." The only difference is that the decubitus ulcers in his cases were healed by a thin layer of epithelium prior to the operative procedure.

### PREOPERATIVE CONSIDERATIONS

The patient paralyzed from a spinal cord injury frequently presents a difficult nutritional problem. Because of their poor appetite it was often difficult to persuade them to take sufficient nutrition by mouth to maintain a

TABLE I  
PLASMA ASCORBIC ACID LEVEL

	Variation Mg. Per Cent	Average Mg. Per Cent
8 patients with poor appetites.....	0.19—0.39	0.29
18 patients with good appetites.....	0.33—0.78	0.57
11 normal controls.....	0.65—1.42	0.96

positive nitrogen balance or to gain weight. In accordance with Army directives, paraplegic patients were given at least 3,500 calories a day. To accomplish this the food had to be inviting and well prepared. Extra nourishment was given between meals and at night. The daily protein intake was at least 125 Gm. a day. When this could not be accomplished by mouth the diet was supplemented by intravenous protein digests. In addition to the vitamins in the diet, supplemental vitamins were usually administered.

It was desirable that the levels of serum protein and hemoglobin should be as close to normal as possible before operation. When indicated, patients were treated vigorously with repeated blood transfusions, plasma infusion and intravenous protein digests or amino-acids before and after operation. In the first 27 patients operated upon, the average hemoglobin before operation was 13.7 Gm. per cent (varying between 10.9 and 15.9 Gm. per cent). The serum protein levels prior to operation averaged 6.4 Gm. per cent (varying between 5.8 and 7.2 Gm. per cent). However, as Abbott and Mellors<sup>1</sup> have shown, the hematocrit and plasma protein may be near normal values even when a relatively large deficit exists in the total number of red blood cells or the quantity of circulating plasma protein. Consequently, in addition to normal levels of hemoglobin and plasma protein, we also considered a good appetite and a steady gain in weight as desirable before operation.

The plasma vitamin C level was determined in 26 patients with paraplegia (Table I.). It can be seen that those patients who had poor appetites had low levels of ascorbic acid in their plasma, approximately one-half that found in the patients with good appetites. Crandon and Lund<sup>7, 8</sup> have shown, in a classical experiment on a human subject with a pure vitamin C deficiency, that a wound will heal adequately even though the plasma ascorbic acid has been zero for as long as 44 days. However, in this human subject there were no other vitamin deficiencies. In actual practice such a state of affairs is probably never found, and we believe that a plasma ascorbic acid level below 0.5 mg. per cent indicates a low saturation of the body with not only vitamin C but also other vitamins. Hence, in all our patients who were eating poorly, supplemental daily doses of vitamin C and other vitamins were given.

It is preferable, of course, to have a clean, healthy looking ulcer with red granulations surrounded by a margin of growing epithelium. Under these circumstances the patient's nutrition is probably good and there is evidence that the essential materials for wound healing are present. However, we have successfully operated upon patients in whom the ulcer bed was covered with dirty gray unhealthy looking granulations, and where there was no epithelial proliferation at the margins of the ulcer. Undermining of the margins of the ulcer and the presence of deep pockets are not a contraindication to operative closure, though they increase the technical difficulties.

All sloughing tissue should be excised before operation in order to diminish the surface infection and to have better visualization of the extent of the ulcer. The following organisms were cultured from the surface of the ulcers: *Bacillus pyocyaneus*; *Escherichia coli*; *Bacillus proteus*; hemolytic *Staphylococcus aureus*; nonhemolytic *Staphylococcus aureus*; *Staphylococcus albus*; beta-hemolytic *Streptococcus*. No special attention was paid to the bacterial flora present. Only cellulitis or inadequately drained pockets of pus were considered to contraindicate operation.

#### TECHNIC

If there was an indwelling catheter, either urethral or suprapubic, it was left open to drain into a bottle during the course of the operation. In one instance, through an oversight, the catheter remained clamped and an upper urinary tract infection resulted. In most cases no anesthesia was required. In a few patients with low injuries of the spinal cord local infiltration with novocaine was necessary to block off painful impulses from the upper portion of the operative area.

The entire bed of the ulcer including undermined margins and pockets together with the surrounding skin were thoroughly washed with soap and water. The skin and ulcer were then cleansed with ether and painted with tincture of mercuric iodine. Two semilunar incisions encircling the ulcer were made through the normal skin, just beyond the thin epithelium covering the scarred borders of the ulcer. The entire ulcer, with its pockets and its base,

# CLOSURE OF DECUBITUS ULCERS

was then removed in one piece. Sometimes the base had to be actually shaved off the sacrum. During the process the gloved hands of the operator and assistants never touched the surface of the ulcer. All instruments which had come in contact with the skin or the surface of the ulcer were discarded.

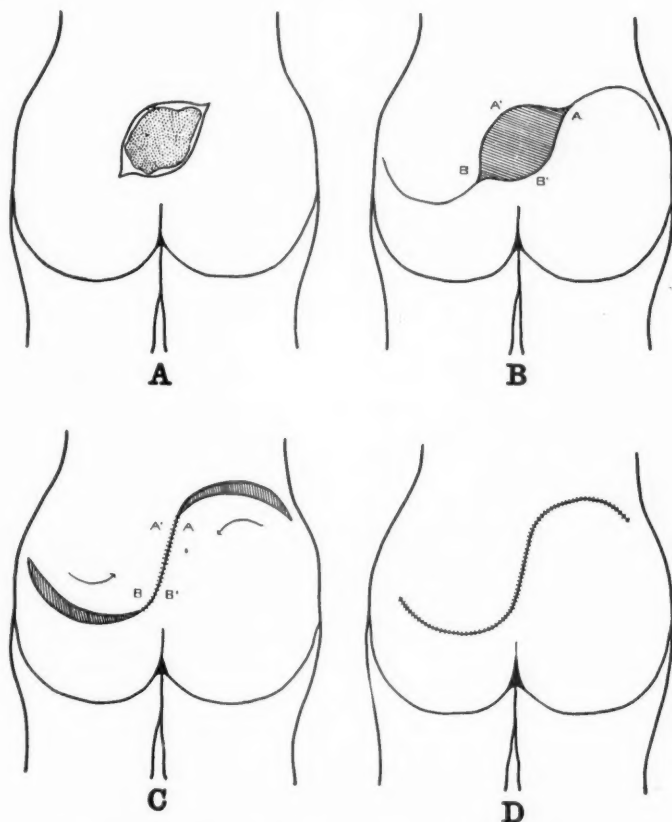


FIG. 1.—Drawings illustrating steps in the operation.

(A) The stippled area represents the ulcer and the heavy lines the two semilunar incisions about the ulcer.

(B) The shaded area represents the raw surface after excision of the ulcer. The curved extensions of the incision are shown.

(C) The skin flaps have been mobilized, rotated toward the midline, and partially sutured.

(D) Suturing completed. Note broad bases of skin flaps and absence of sharp angles.

From then on the operation was carried out as though it were in a completely clean field.

Small ulcers, 1 to 2 cm. in diameter, could frequently be excised between two semilunar incisions and the resulting defect closed by mobilizing the skin margins and suturing them together in a straight line. This method cannot be used to close large ulcers. In these cases long curved extensions of the

incision were made on each side beginning where the tips of the original semilunar incisions met (Fig. 1 A,B,C,D). The concavity of the curve was reversed on opposite sides. The incision was carried down through the subcutaneous tissue to the fascia overlying the gluteus maximus muscles in

FIG. 2

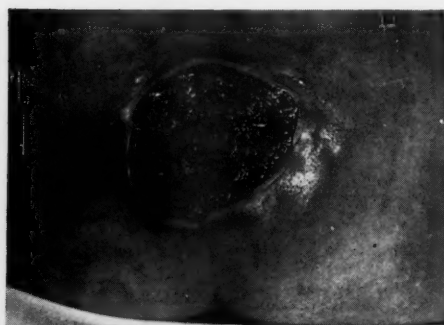


FIG. 4

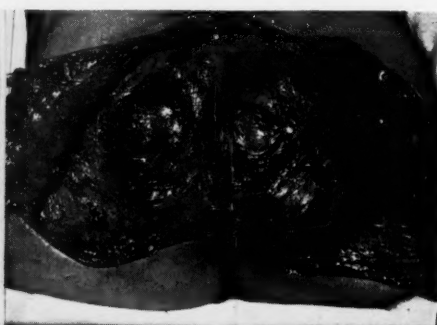


FIG. 3



FIG. 5

FIG. 2.—Sacral decubitus ulcer on H. M. at the time of operation, July 9, 1945. The ulcer measured 7x7.5 cm., with a border on the left which was undermined for 1.5 cm. and a thin scar on the right 1 cm. in width.

FIG. 3.—The entire ulcer with surrounding scar and undermined edge has been excised between two semilunar incisions, extending from above on the right to below on the left. Curved extensions of the incision have been made to develop flaps for rotation. The concavity faces upward on the left and downward on the right.

FIG. 4.—The skin flaps are retracted to show the extent of undermining. Note the broad bases of the skin flaps. The plane of separation is between the subcutaneous tissue and the fascia overlying the gluteus maximus muscles.

FIG. 5.—The flaps have been rotated, as shown in Fig. 1-C, and sutured together with buried stitches of fine cotton in the subcutaneous tissues and silk sutures in the skin. Note the absence of any sharp angles. No drains were used in this case. The wound healed *per primam*, and there has been no recurrence of the decubitus ulcer.

the back in sacral decubiti, or the fascia lata in the thighs in ulcers overlying the femoral trochanters. The skin and subcutaneous tissue flaps were then widely mobilized, the plane of cleavage being between the fascia and the fat. The extent of undermining in a moderate-sized ulcer is shown in Figure 4. It is important always to insure that the flaps have a broad base. Once

## CLOSURE OF DECUBITUS ULCERS

serious difficulty was encountered with the blood supply of a flap because of failure to adhere to this principle (Fig. 11).

After mobilization the flaps were rotated and drawn toward one another. The mobilization should be extensive enough so that the flaps can be sutured together with a minimum of tension. The rotation of the flaps is illustrated in Figure 1 C, and the suture line after closure is shown in Fig. 1 D and Fig. 5. This type of procedure was used in the majority of our cases. Some ir-

FIG. 6



FIG. 8



FIG. 7

FIG. 9

FIG. 6.—The result four weeks after operative closure of a sacral decubitus ulcer in S. by similar technic.

FIG. 7.—The result in R. six months after operation in one of the largest sacral decubitus ulcers operated upon. The transverse diameter of this ulcer was 14 cm. and the vertical diameter was 8 cm.

FIG. 8.—Decubitus ulcer in L. six months before operation. At time of operation, August, 1945, the ulcer measured 7 cm. in transverse diameter and 3.5 cm. vertically. There was a 3-cm. scar extending down to the gluteal fold and 1.5-cm. undermining on the right and 5-cm. undermining on the left.

FIG. 9.—The result five months after operative closure in L. The scar of the incision on the right can be seen as a thin line extending laterally just below the right posterior superior iliac spine.

regular ulcers (Fig. 10) required a modified technic but throughout our series two main principles were observed whenever possible. Skin flaps were made with bases that were very broad in relation to the length of the flaps. Skin margins were cut smoothly in curves avoiding corners and sharp angles. The technic described here is thought to be safer than that described by



Croce, *et al.*<sup>9</sup> They advanced a number of small, long, narrow flaps with corners at the free extremities instead of using broad curved flaps which avoid angles.

Two methods were used for hemostasis. In approximately three-fourths of the operations fine cotton (No. 120) was used for ties. In the remaining one-quarter the bleeding points were coagulated with electric current. There appeared to be little difference between the two methods in the healing of the wounds. Toward the end of our series, electrocoagulation was used more frequently because it increased the operative speed, a consideration of some importance in these patients. It was obviously dangerous for the patients to lie prone on the operating table longer than two hours, because of the possibility of developing decubitus ulcers over the anterior iliac spines.

Before suturing the flaps together at the conclusion of the operation the entire wound was thoroughly irrigated with sterile warm salt solution. Suturing was then begun in the central portion of the wound (Fig. 1 C). A series of interrupted stitches of No. 80 cotton were placed at very close intervals in the subcutaneous tissues close to the skin. The stitches were so placed that, when tied, the knots would lie in the deeper portion of the wound. None were tied until the entire row was in place. Traction was then made on all the threads drawing the wound together while each stitch was tied. This distributed the tension and prevented the cutting-through or breaking of the individual stitch. Cotton was invariably used for buried suture material. Only in rare instances was thread heavier than No. 80 required for sutures. Number 120 thread was used for ties. In our later cases cotton was also used for skin sutures instead of silk because it appeared to produce less reaction.<sup>18</sup>

Because of the extensive dissection required to close large ulcers, one or two rubber tissue drains were frequently placed in the angles of the wound as a precaution against the accumulation of serum. These drains were removed in 24 or 48 hours. A dressing of fluffed gauze and cotton waste was applied at the close of the operation and held firmly in place with transverse strips of elastic adhesive tape. Before applying adhesive plaster the skin was carefully cleansed with ether and painted with compound tincture of benzoin. This proved of value in preventing excoriation and pustule formation under the adhesive.

Postoperatively, it was inadvisable to allow the patient to remain in the prone position for any great length of time because of the danger of developing decubitus ulcers over the anterior superior iliac spines. The patient could lie on his sides for short intervals of time but, here too, the danger of skin necrosis over the trochanters of the femurs was always present. Consequently after the first 24 or 48 hours the patient was permitted to lie in a supine position for as long as two hours. In recent cases the Stryker frame has been used and the patient turned from prone to supine position and back again regularly every two hours.

Intramuscular penicillin was administered to all patients starting the

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morning of operation and continuing during the postoperative course until it was evident that the wound was healing properly without infection. In a few of the earlier operations sulfanilamide crystals were lightly dusted into the wound or a solution of penicillin was introduced before closure. In all the later cases the local use of drugs was abandoned. There was no increase in the incidence of infection in these cases. Of more importance in the primary healing of the wound is a meticulous operative technic, with the avoidance of tension and contamination, and the use of fine cotton for suture material.

Sutures were removed usually on the eighth day, but sometimes as early as the seventh or as late as the 11th postoperative day, depending upon the appearance of the wound, the degree of tension, and whether the sutures were cutting through the skin. A dressing was kept on the wound until it was soundly healed, moderately firm pressure being maintained by means of elastic adhesive.

TABLE II

### RESULTS WITH EXCISION AND PRIMARY CLOSURE

Healed primarily.....	44
Healed in four weeks.....	6
Healed in eight weeks.....	4
Improved.....	5
Failures.....	5
Death, eighth day.....	1
Total.....	65

Sometimes, after the wound had healed collections of serum occurred beneath the skin. These were usually treated successfully by one or more aspirations with a needle and the continued application of a pressure dressing. Occasionally penicillin solution was injected through the needle after the aspiration of serum. In a few instances cotton sutures have been extruded from a wound several weeks after it appeared to be soundly healed.

### RESULTS

Table II summarizes the results obtained in the operative closure of 65 ulcers in 43 patients. Twenty-nine were sacral ulcers and 26 were ulcers overlying the femoral trochanters. The remaining ten ulcers had a miscellaneous distribution, including three ulcers over the tuberosities of the ischium, a result of sitting too long in a wheel chair. Primary healing occurred in 44 ulcers, or 68 per cent. If the first four categories of Table II are grouped together one might characterize 90 per cent of the operative results as satisfactory.

In the six instances in which the wounds were healed in four weeks the delay was caused in four of them by a slight separation of the wound edges where there was the greatest tension. In the fifth case there was some superficial infection around a skin suture and in the sixth case an hematoma formed which had to be evacuated.

In the four cases which were healed in eight weeks, one had sero-sanguineous drainage which later became purulent before it finally cleared up. In two there was some separation of the skin edges. Both wounds were

FIG. 10

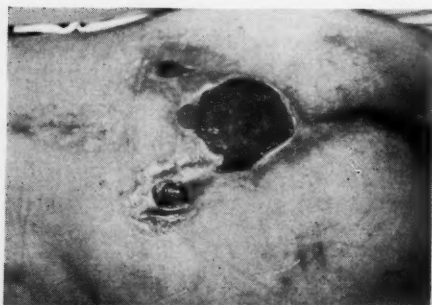


FIG. 12



FIG. 11

FIG. 13

FIG. 10.—Sacral decubitus ulcer in C., with two typical small ulcers over the posterior superior iliac spines six months before operation. At the time of operation a large portion of the granulating area was covered with a thin layer of epithelium which broke down readily with slight trauma.

FIG. 11.—The end-result in C. five months after operation. This result was classified as a failure. The flap on the left side was undermined too extensively for the width of its base and there was sloughing of the margins of the flap in two areas, as can be seen in the photograph. The scar of the lower portion of the left-hand flap is partially obscured by the sheet. There was also some sloughing of the skin margins overlying the right posterior superior iliac spine. The wound has healed with the aid of small deep skin grafts.

FIG. 12.—The result of closure of the decubitus ulcer on the right hip in J. M. four months after operation. The ulcer measured 4x3.5 cm. and there was a 2-cm. undermining beneath the anterior and superior border of the ulcer. The usual curved incisions were made and skin flaps rotated to close the defect after excision of the ulcer. The wound healed *per primam*.

FIG. 13.—The result two months after excision of a decubitus ulcer over the right hip in E. The ulcer was long and narrow and extended from the greater trochanter of the femur down over the shaft. The length of the ulcer necessitated some modification of the usual curved flaps.

completely healed in eight weeks, one with the aid of small deep grafts. In the fourth instance the ulcer was extremely dirty and before operation showed no sign of healing. There was mild infection and some drainage, but the wound was completely healed in eight weeks.

Five results are classified as improved. In three cases there was some separation of the skin edges with persistent small ulcerations at the end of

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eight weeks. In another a slightly larger defect healed with the aid of small deep grafts. In the fifth case an ulcer over the right hip was operated upon and the skin sutures were removed by mistake on the fifth day, with some separation of the wound edges. Ten weeks later there was a small persistent ulceration in the central portion of the incision. Three months after the first operation the patient was reoperated upon, with primary healing of the wound.

Five operations are classified as failures, and one death occurred on the eighth postoperative day. The death was from pneumonia associated with a severe urinary tract infection. At the time of death on the eighth day, the wound was perfectly clean and appeared to have healed *per primam*. Three of the five failures were due to infection with complete breakdown of the wound. In the fourth case there was too much tension on the suture line. The sutures cut through and there was separation and gaping of the wound. The fifth case is illustrated in Figures 10 and 11. There was a large raw area to be closed after excision of the ulcer and the incision on the left side was carried very far laterally in a curved fashion. The left limb of the "Y" defect after excision of the ulcer resulted in a dangerously narrow base to the flap which was unusually long. At the time of closure the skin margins were cyanotic and later sloughed. The wound eventually healed, with the aid of small deep grafts.

### SUMMARY AND CONCLUSIONS

1. Bedsores are due to pressure on the skin of sufficient magnitude to interrupt the blood supply. This ischemia, when continuous and of sufficient duration, produces necrosis.

2. The term "trophic nerve" should be abandoned. In our opinion, no evidence has been produced to show that an adequate blood supply to the skin, or its nutrition, is dependent upon an intact nerve supply. Our operative experiences confirm the original observations of Brown-Sequard.

3. Malnutrition is a factor in the production of bedsores and delays their healing.

4. The surgical problem presented by a large decubitus ulcer is similar in many respects to a third-degree burn with full-thickness skin loss.

5. The end-results of spontaneous healing and skin grafting are unsatisfactory because they do not provide full-thickness skin and subcutaneous tissue over bony prominences.

6. A method of operative closure of decubitus ulcers has been described. The method involves: (a) Complete excision of the ulcer, its margin and all pockets without contamination of the wound; (b) the formation of skin flaps in the immediate vicinity with curved borders and broad bases; (c) the rotation and advancement of these flaps to cover the skin defect without tension; and, finally, (d) the use of very fine cotton thread for suture material.

7. Sixty-five ulcers were operated upon by this method in 43 patients. Primary healing took place in 44 operations, or 68 per cent. The results could be regarded as satisfactory in 59 operations, or 90 per cent.



8. Complete excision and immediate plastic closure is the best method of treating bedsores in young patients with paraplegia.

## REFERENCES

- <sup>1</sup> Abbott, W. L., and Mellors, R. C.: Total Circulating Plasma Proteins in Surgical Patients with Dehydration and Malnutrition. *Arch. Surg.*, **46**, 277, 1943.
- <sup>2</sup> Blair, V. P., and Brown, J. B.: The Use and Uses of Large Split-Skin Grafts of Intermediate Thickness. *Surg., Gynec. & Obst.*, **49**, 82, 1929.
- <sup>3</sup> Brown-Sequard, E.: *Experimental Researches Applied to Physiology and Pathology*. H. Bailliere, New York, 1853, p. 16.
- <sup>4</sup> Charcot, J. M.: *Lectures on the Diseases of the Nervous System*. Delivered at La Salpêtrière. Translated from the Second Edition by Sigerson, G., Henry C. Lea, Philadelphia, 1879.
- <sup>5</sup> Cohnheim, J.: *Lectures on General Pathology*. London, The New Sydenham Society, 1889. Part II—The Pathology of Nutrition, p. 544.
- <sup>6</sup> Cope, V. Z.: Prevention and Treatment of Bedsores. *British M. J.*, **1**, 737, April 8, 1939.
- <sup>7</sup> Crandon, J. H., and Lund, C. C.: Vitamin C Deficiency in an Otherwise Normal Adult. *New England J. of Med.*, **222**, 748, May, 1940.
- <sup>8</sup> Crandon, J. H., Lund, C. C., and Dill, D. B.: Experimental Human Scurvy. *New England J. of Med.*, **223**, 353, September 5, 1940.
- <sup>9</sup> Croce, E. J., Schullinger, R. N., and Schearer, T. P.: The Operative Treatment of Decubitus Ulcers. *ANNALS OF SURGERY*, **123**, 53, January, 1946.
- <sup>10</sup> Davis, J. S.: The Small Deep Graft: Relationship to the True Reverdin Graft. *ANNALS OF SURGERY*, **89**, 902, June, 1929.
- <sup>11</sup> Davis, J. S.: Operative Treatment of Scars following Bedsores. *Surgery*, **3**, 1, January, 1938.
- <sup>12</sup> Freeman, L.: *Keen's System of Surgery*, Vol. I. W. B. Saunders, Philadelphia, 1907.
- <sup>13</sup> Hofmann, H. M.: Sawdust Beds: Summary of Seven Years Experience. *Mod Hosp.*, **56**, 49, March, 1941.
- <sup>14</sup> Lamon, J. A., and Alexander, E. Jr.: Secondary Closure of Decubitus Ulcers with the Aid of Penicillin. *J. A. M. A.*, **127**, 396, February, 1945.
- <sup>15</sup> Lanman, T. H., and Ingolls, T. H.: Vitamin C Deficiency and Wound Healing. *ANNALS OF SURGERY*, **105**, 616, 1937.
- <sup>16</sup> Lewis, T., and Grant, R.: Observations upon Reactive Hyperemia in Man. *Heart*, **12**, 73, June, 1925.
- <sup>17</sup> Lister: De l'influence de la Position des Membres sur la Circulation. *Bull. d. l'Acad. d. Med. (Paris)* Second Series, **7**, 640, 1878.
- <sup>18</sup> Meade, W. H., and Ochsner, A.: The Relative Value of Catgut, Silk and Cotton as Suture Material. *Surgery*, **7**, 485, April, 1940.
- <sup>19</sup> McCormick, W. J.: The Nutritional Aspects of Bedsores. *Med. Rec.*, **154**, 389, November, 1941.
- <sup>20</sup> Mulholland, J. H., Co Tui, Wright, A. M., Vinci, V., and Shafiroff, B.: Protein Metabolism and Bedsores. *ANNALS OF SURGERY*, **118**, 1015, December, 1943.
- <sup>21</sup> Munro, D.: Care of Back Following Spinal Cord Injuries: Consideration of Bedsores. *New England J. Med.*, **223**, 391, September 12, 1940.
- <sup>22</sup> Paget, J.: Clinical Lecture on Bedsores. *Student's J. and Hosp. Gaz. (London)*, **1**, 144, 1873.
- <sup>23</sup> Thévenet, V.: Sur l'Emploi du Caoutchouc Alvéolé dans le Traitement Préventif ou Curatif de l'escarre Sacrée. *Lyon Méd.*, **157**, 709, June 14, 1936.
- <sup>24</sup> Thompson, W. D., Ravdin, I. S., and Frank, I. L.: Effect of Hypoproteinemia on Wound Disruption. *Arch. Surg.*, **36**, 500, March, 1938.
- <sup>25</sup> Trumble, H. C.: The Skin Tolerance for Pressure and Pressure Sores. *Med. J. Australia*, **2**, 724, 1930.



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**DISCUSSION.**—**DR. CHARLES C. LUND**, Boston, Mass.: Although I have had no experience in the care of paraplegia, the problems of bedsores are comparable to the problems in the chronic stage of severe burns, and the experience from the use of high protein diets in burns should be useful in the care of patients with paraplegia. The first principle of diet is to get as much in by mouth as possible. Intravenous protein and glucose should be used only as supplementary diets in clinical work. Our experience has led us to believe that any fat in the diet of these patients causes distress, distension and diarrhea; therefore, we take all the fat out of the diet.

For our most severe patients we now use a diet containing 50 per cent carbohydrate and 50 per cent protein with very high calories. If an attempt is made to give such a diet with ordinary food, poor appetite usually will lead to the patient's picking the wrong items from a tray. Therefore, we concentrate on preparing a "burn drink" which we insist that the patient take. If this is taken we then do not worry how much solid food the patient eats. This diet is based on skim-milk which is skimmed in a separator, to which is added 10 per cent by weight of skim-milk powder, and 5 per cent by weight of Amigen powder, plus 1 per cent by volume of Valentine's liver extract. Such a mixture made on the basis of three liters of skim-milk will have a volume of about 3,200 cc., 250 cc. of which should be given every two hours day and night. This will provide 2,500 calories and 325 grams of protein. One patient has taken this mixture on the basis of four liters of skim-milk for a period of many weeks. If it is necessary to increase the protein still more, it can be done by reducing the amount of skim-milk powder and increasing the amount of Amigen, but such a mixture becomes relatively unpalatable, and, therefore, difficult to drink. Under these conditions, some patients should be fed this mixture by stomach tube. Generous doses of all vitamins should be added to this mixture, but do not need to be discussed at this time.

**DR. ROBERT H. IVY**, Philadelphia, Pa.: The essayists have presented two very excellent papers on the closing of defects. Theoretically, I would say the method used by Doctors White and Hamm is superior, probably, to that used by Doctor Gibbon, because in the former the new skin flap covers the area of the ulcer, whereas in Doctor Gibbon's method there is a line of suture over the original site of the ulcer. Practically speaking, however, the results of the two methods are equally good.

**DR. FRANK L. MELENEY**, New York City: I think Doctors White and Gibbon are to be congratulated on the high percentage of primary healing which they have achieved. I would be interested to know if careful bacteriologic studies were made in their cases and if they have made an analysis of their failures; particularly, to find out whether the element of infection was a factor in these failures. The organisms contaminating bedsores are usually of intestinal origin and are of low virulence and are not susceptible to penicillin. However, there are antibacterial agents available by which it is possible to minimize their activity, and by their use it might be possible to attain a still higher percentage of success.

**DR. ROBERT H. KENNEDY**, New York City: I have been much interested in this work. We should stop to consider that these two presentations represent dramatic methods and results which few people dreamed of as recently as three years ago. At the present time, closure of decubitus ulcers is largely taken in stride at the various Centers. The muscles are atrophied, so that skin and subcutaneous tissue can be moved quite a distance. These are long operative procedures, often three, four or five hours. I have seen nonabsorbable sutures used throughout and the results have been good. There is a striking change in the patient from the time the ulcer is closed.

He begins to have a good appetite and there is little difficulty in keeping him in positive protein balance.

CAPTAIN JAMES C. WHITE, Boston, Mass. (closing): I want to thank the discussers very much for their useful suggestions. Doctor Meleney asked about how much we had analyzed types of bacteria and the relationship of bacteria to failure. Most of the organisms were *anaerobic Streptococci*, *B. proteus*, *B. coli*, and *B. pyogenes*; but with these there were hemolytic streptococci and staphylococci. It is interesting to speculate on the effect of penicillin on the predominant type of organism. Is it really effective on organisms other than streptococci and staphylococci? We have not used streptomycin. I think the use of sulfasuxidine should be helpful. In our single failure I feel it was not due to the organism but to the poor condition of the patient. This man had tremendous loss of weight, a compound fracture of the humerus, and had had to have a cordotomy done for pain. In addition, he had had an adhesive peritonitis with partial intestinal obstruction. We closed an ulcer over the greater trochanter. There were others over the sacrum and the opposite trochanter which we were anxious to get closed because he could only lie on his right side. We tried suturing the ulcer over the other trochanter and this plastic repair broke down completely. The patient with separation of the flaps, however, had the same type of organisms, but, nevertheless, we were able to secure a satisfactory closure after secondary suture.

In dealing with some of these Marine Corps casualties who had other serious injuries and advanced malnutrition, we found intravenous amino-acids of great assistance, provided we could get an early improvement in nitrogen balance and the patient could be induced to take an adequate intake by mouth. Unfortunately the patients tolerate nasal feeding very poorly. After a few weeks intravenous feeding becomes most difficult because of thrombosis of veins and protein sensitization. One man, in whom in desperation a jejunostomy was performed, promptly developed a local area of peritonitis and obstruction. On the other hand, all our uncomplicated cases did well.

I wish we could have had advance information on the papers on burns that were read Tuesday evening. The extensive bedsores constitute a very similar problem; they all show red blood cell destruction. I think Doctor Lund's suggestion concerning the need for massive doses of vitamin C is most appropriate, particularly, as we did not want to give large amounts of fruit juice, feeling that this would increase the alkalinity of the urine. Finally, pyruvic acid paste might be helpful in getting rid of the sloughs and thereby expediting the date for plastic closure of these lesions.

DR. JOHN H. GIBBON, JR., Philadelphia, Pa. (closing): I am sorry Doctor Freeman is not here. He helped in all these cases and operated upon a number of them.

In answer to Doctor Meleney, I feel as Doctor White does. We cultured all these ulcers and found approximately the same variety of organisms that Doctor White mentioned. Our failures were not associated with any particular organism. They were due to three factors—tension, malnutrition and, in one instance, because we cut a flap with a narrow base. We preferred, as Doctor Kennedy said, to have an ulcer with clean granulations and a margin of epithelium before performing an operative closure, but we have not hesitated to operate where there were undermined pockets. You can dissect these out and not buttonhole them; after that you are working in a clean field. We used cotton and found it satisfactory; we have had no experience with catgut. The operating time, as Doctor Kennedy pointed out, can be quite long. I think we rarely exceeded two and one-half hours. The operative time is of importance because of the danger of development of pressure sores over the anterior superior spines from prolonged immobility in the prone position.

## STUDIES ON NUTRITION\*

### THE EFFECT OF PREOPERATIVE FORCE-FEEDING ON SURGICAL PATIENTS

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If a large positive nitrogen balance can be induced in the average adult by an intensive feeding program lasting a few days there should be definite advantages in using this method to anticipate the nitrogen deficits of the postoperative period. Most studies of the protein requirements of surgical patients have been focused on the postoperative period when nitrogen output is high. Unfortunately, the problem of feeding certain groups of patients during this period is a difficult one often requiring special technics such as intravenous or orojejunal feedings. It seemed desirable, therefore, in those patients who could take food by mouth readily before operation to see if a large enough positive nitrogen balance could not be induced by a vigorous feeding program before operation to avoid the necessity of attempting to maintain nitrogen balance in the early postoperative period under trying and difficult circumstances.

The development of protein hydrolysates, as Co Tui<sup>1</sup> and his associates have pointed out, makes it possible to provide very high intakes of food nitrogen without excessive bulk.

Earlier studies at the University of Pennsylvania indicated that patients recovering from gastric and intracranial operations generally were in negative nitrogen balance during the first five days after operation and tended to regain positive balance in the second five days in most instances.<sup>2,3</sup> Guided by this experience, and that of others, it was decided to study a group of patients for five days before operation on a force-feeding regimen and for five days after operation on what may be termed a "*laissez faire*" regimen. In addition to showing how much nitrogen could be accumulated with five days of forced feeding, this plan would permit an estimate of the extent to which nitrogen loss was accentuated or increased during the five days subsequent to this period as compared with patients being studied on various postoperative feeding regimens. It also seemed important to observe whether or not the patients were noticeably benefited by the preoperative force-feeding regimen. Because clinical impressions are so apt to be misleading, we sought

\*The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and the University of Pennsylvania.

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objective means of measuring these possible benefits. In our previous studies<sup>4, 5</sup> certain tests of the response of the circulation in convalescence appeared to be among the most sensitive available for our use. For that reason we selected the response of the patients' circulation to changes in position on a tilt-table equipped with a footboard.<sup>6</sup> In addition, the status of the circulation including the cardiac output was studied by means of a portable ballistocardiograph<sup>7</sup> as a means of comparing the two groups.

#### PROCEDURE

At first patients were placed in the force-fed group or in the control group in rotation. As our studies progressed and as we became convinced of the benefits of the force-feeding regimen, several patients who were poor operative risks were placed in the force-feeding group in an effort to improve their care although they ordinarily would have been control patients. Thus, the treated series may have been weighted unfavorably with poor risk patients.

The patients were weighed at the start of the period of observation on a special balance used for metabolic studies. Serum protein concentration, plasma volume, cardiac output, and the response to tilting were determined at that time, and these tests were repeated just before operation and at the close of the fifth postoperative day in the force-fed group. The group serving as controls was tested before the day of operation and at the close of the fifth postoperative day. Cardiac output and the response of the circulation to tilting were determined in most patients at additional postoperative intervals.

The diets were calculated on the basis of body weight, and patients were fed a diet aimed to provide them with three times the nitrogen which we had usually found to be adequate to produce postoperative nitrogen equilibrium.<sup>2</sup> We attempted to feed each patient about 0.9 Gm. of nitrogen per kilogram per day and in those where 0.9 Gm. per kilogram was impossible succeeded in keeping nitrogen intake above 0.8 Gm. per kilogram per day. Three palatable meals were provided most patients each day. Additional protein was supplied as hydrolysates of casein\* or lactalbumin† at intervals of several hours while patients were awake. While the feeding of protein hydrolysates in such quantity as was necessary in these studies is difficult to achieve, it was accomplished in most individuals. The objectionable taste of the interval feedings was overcome for most patients by the use of a fruit juice or chocolate milk as a vehicle or the addition of essence of peppermint as a flavoring agent. Several patients were fed by stomach tube. No serious side-effects were noted, although diarrhea occurred in a few. This symptom was controlled with camphorated tincture of opium. The abdominal distention encountered with the protein hydrolysates in postoperative jejunal feedings was not seen in this preoperative group.

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\* Amigen supplied by Mead, Johnson & Co.

† Lactamin (lactalbumin hydrolysate) supplied by Wyeth, Inc.



The collection of specimens and the analytical methods were the same as described in a previous paper.<sup>2</sup> Circulatory studies necessitating the use of the ballistocardiograph were made possible through the assistance of Dr. Robert Mayock, under the direction of Dr. Isaac Starr, and are reported in detail elsewhere.<sup>7</sup> The responses of patients to changes in position on the tilt-table were observed.

Eleven patients were studied in the force-fed group (Table I); there were two gastric resections, two colectomies, and seven craniotomies. Preoperatively, the interval feedings in seven patients consisted of Amigen, and in four of lactalbumin hydrolysate. Postoperatively, four patients were given intake of 0.23 Gm.N/Kg./day or over, and 30 calories per Kg./day and seven patients were followed on the usual hospital regimen of intravenous glucose and food on the fourth or fifth day.

Twelve patients were used as "controls" (Table II). The operations which they had performed consisted of five gastrectomies, two colectomies and five craniotomies. They were given diets consisting of intravenous glucose plus hospital diet, gastrostomy or intravenous protein hydrolysate postoperatively. Four patients received intakes which should have been sufficient to achieve nitrogen equilibrium. Postoperatively, the daily average nitrogen intake in the force-fed group ranged from 0.01 to 0.28 Gm./Kg. and in the control group from 0.01 to 0.52 Gm. per kilogram per day. The average intake for the post-operative period was slightly higher in the control group.

It should be emphasized that when there is reference to the "force-fed group," it refers to force feeding only in the preoperative period.

#### RESULTS

*The Effect of Force-feeding on Nitrogen Balance.*—Large positive balances accumulated in every case during the force-feeding regimen. The extremes were 57.6 Gm. and 148.0 Gm. for the five-day period, and the mean was 92.2 Gm. or 18.4 Gm. per day. Thus, the daily gain was greater than the nitrogen content of one-half a pound of fresh muscle.

In 10 of the 11 patients there was a positive balance when the two periods were combined. The balances ranged from a minimum of -3.1 Gm. to a maximum of +113.3 Gm., with a mean of 55.2 Gm. for the ten days for the 11 patients. The results are tabulated in Tables I and II.

*Serum Protein Concentration.*—Preoperatively, in the force-fed group six of the 11 patients sustained a fall in serum protein concentration while five remained the same or showed an increase. However, all changes but one were minor ones, and one of the two who showed a rise in serum protein concentrations had an initial level below 7.5 Gm. per 100 ml. Postoperatively, there was little difference between the force-fed and control groups.

*Plasma Volume and Total Circulating Plasma Proteins.*—Plasma volume determinations were completed in 12 of the control patients and in eight of the force-fed group. In these cases it was possible to calculate the total circulating plasma protein. The plasma volume determinations and the total circulating plasma protein figures have been compiled in Table III.



TABLE I  
 TREATED GROUP  
 ELEVEN PATIENTS WHO RECEIVED FORCED FEEDING FOR FIVE DAYS BEFORE OPERATION

Patient	Operation	Preoperative Feeding	Postoperative Feeding	Intake						Output					
				Total Nitrogen		Nitrogen /Kg./Day		Calories /Kg./Day		Total Nitrogen		Nitrogen Balance		Nitrogen Balance	
				Preop. 5 days	Postop. 5 days	Preop.	Postop.	Preop.	Postop.	Preop.	Postop.	10 Days	5 Days	10 Days	5 Days
				Gm.	Gm.	Gm.	Gm.	Cc.	Cc.	Gm.	Gm.	Gm.	Gm.	Gm.	Gm.
Rl.	Craniotomy	Amigen + hospital	Hospital	274.3	36.3	0.82	0.11	45	21	126.3	92.3	+ 92.0	+ 148.0	+ 56.0	- 56.0
Fc.	Craniotomy	Lactalbumin + hospital	Hospital	302.8	26.7	0.89	0.08	49	15	168.6	95.5	+ 65.4	+ 134.2	+ 68.8	- 68.8
Sm.	Gastric resection	Amigen + hospital	I.V. glucose + hospital	275.5	20.7	0.89	0.07	44	15	165.4	49.7	+ 81.1	+ 110.1	+ 29.0	- 29.0
Ho.	Craniotomy	Amigen + hospital	Gastrostomy + hospital	220.2	41.2	0.77	0.14	45	21	152.1	69.4	+ 39.9	+ 68.1	+ 28.2	- 28.2
Wa.	Rankin resection	Amigen + hospital	I.V. glucose	193.6	5.8	0.70	0.02	50	10	136.0	66.5	- 3.1	+ 57.6	- 60.7	- 60.7
Do.	Rankin resection	Lactalbumin + hospital	I.V. glucose	244.6	7.8	0.80	0.02	39	6	163.7	68.8	+ 19.9	+ 80.9	+ 61.0	- 61.0
Pa.	Gastric resection	Lactalbumin + hospital	I.V. glucose	260.2	2.6	0.83	0.01	38	8	146.7	47.5	+ 68.6	+ 113.5	+ 44.9	- 44.9
Th.	Craniotomy	Amigen + hospital	Hospital	271.7	71.4	0.86	0.23	42	26	200.3	96.8	+ 46.0	+ 71.4	+ 25.4	- 25.4
Wl.	Craniotomy	Amigen + hospital	Hospital	282.2	86.0	0.83	0.25	46	26	195.3	98.2	+ 74.7	+ 86.9	+ 12.2	- 12.2
Bo.	Craniotomy	Amigen + hospital	Hospital	319.8	100.7	0.89	0.28	50	27	181.7	125.5	+ 113.3	+ 138.1	+ 24.8	- 24.8
Sc.	Craniotomy	Lactalbumin + hospital	Lactalbumin + dextrin-maltose	210.0	85.3	0.78	0.25	49	26	111.5	119.0	+ 64.8	+ 98.5	+ 33.7	- 33.7

## STUDIES ON NUTRITION

Only one of the eight force-fed patients had more circulating plasma protein at the end of the ten-day study than at the beginning of the feeding regimen. It is of interest that this patient was the only individual among the eight whose initial serum protein concentration was below 6.0 Gm. per 100 ml. If, however, one considers only the period from operation to the end of the first five postoperative days one finds that three of the eight patients had an increase in total circulating plasma protein as compared with five of 12 of the control patients who were studied only during this period.

The changes in the serum protein concentration and total circulating serum protein in the force feeding period are contrary to what one would

TABLE II  
TWELVE PATIENTS WHOSE NUTRITION IN THE PREOPERATIVE PERIOD WAS NOT STUDIED

Patient	Operation	Feeding	Intake			Output	
			Total Nitrogen	Nitrogen	Calories	Total Nitrogen	Nitrogen
			5 Days Gm.	/Kg./Day Gm.	/Kg./Day	5 Days Gm.	Balance Gm.
McG.	Gastric resection	I.V. glucose	1.8	0.01	9	57.3	-55.5
Ka.	Abdomino-perineal resection	I.V. glucose	6.5	0.02	4	40.7	-34.2
Fa.	Gastric resection	I.V. glucose + hospital	8.0	0.03	9	54.3	-46.3
Ca.	Gastric resection	I.V. glucose + hospital	9.7	0.03	9	40.0	-30.3
Sm.	Craniotomy	Hospital	49.6	0.12	17	72.9	-23.3
Fe.	Craniotomy	I.V. glucose + hospital	32.0	0.13	12	92.5	-60.5
Wi.	Craniotomy	Hospital	34.3	0.17	29	35.4	- 1.1
Bu.	Craniotomy	Gastrostomy	77.9	0.18	19	125.9	-48.0
Le.	Craniotomy	Gastrostomy	60.8	0.22	20	133.3	-72.5
Fat.	Gastro-enterostomy	Casein Aminosol + gelatin	62.4	0.25	28	67.5	- 5.1
Mi.	Colectomy	Casein Aminosol + gelatin	86.0	0.29	29	98.0	-12.0*
Cr.	Gastric resection	Fibrin Aminosol + glucose	117.7	0.52	33	101.4	+16.3

\* Period of study on this patient is for the first five postoperative days. All others are for operative day and four postoperative days.

expect. Both before and after operation the differences are small and the mean figures for protein concentration are within normal limits, so that one would not be justified in drawing either positive or negative conclusions. They do suggest that patients with normal serum protein levels do not store appreciable amounts of protein as plasma protein on the force feeding regimen employed.

*Response to Tilting.*—The reaction of pulse and blood pressure to change in position from the horizontal to 15 degrees from the vertical on a tilt-table was measured in eight of the force-fed and nine of the control patients. As our experience with this test increased, it seemed less sensitive than we had thought at the outset of this work. Many variables enter into the interpretation of the results, and only a brief summary is reported here.

Both groups acted essentially like normal individuals before operation when subjected to changes in position on the tilt-table. The most obvious response to tilting was loss of consciousness when tilted from the horizontal to the vertical position on the fifth postoperative day. Of the eight patients in the force-

TABLE III  
 PLASMA VOLUME AND TOTAL CIRCULATING PLASMA PROTEIN DATA

Patient	Controls						Force-Fed											
	Serum Protein Concentration			Plasma Volume			Total Circulating Plasma Protein			Serum Protein Concentration			Plasma Volume			Total Circulating Plasma Protein		
	Preop. Gm. %	Postop. Gm. %		Preop. Cc.	Postop. Cc.		Preop. Gm.	Postop. Gm.		Preop. Gm. %	Postop. Gm. %		Preop. Cc.	Postop. Cc.		Preop. Gm.	Postop. Gm.	
Fa.	7.8	7.5		3,356	2,712		262	203		7.3	7.0	7.2	—	—		—	—	
Ca.	6.1	6.4		3,132	3,385		191	217		7.6	7.7	7.5	2,227	2,242		169	173	150
Ka.	5.4	5.6		2,100	2,445		113	137		6.8	6.9	5.5	2,500	2,000		170	138	149
McG.	7.2	6.5		2,940	5,555		212	361		6.8	6.7	5.8	3,436	3,636		234	244	149
Sm.	7.4	7.1		4,273	2,762		316	196		7.1	7.0	6.5	2,898	3,048		206	213	196
Bu.	7.6	6.7		2,793	2,976		212	199		5.8	7.4	6.9	2,040*	2,525		118	187	162
Wi.	7.2	7.5		1,519	1,492		109	112		7.2	7.8	7.0	—	—		—	—	
Le.	5.6	6.6		3,105	3,067		174	202		8.0	7.6	7.5	3,080	2,570		246	195	213
Fat.	6.4	6.3		4,201	3,921		269	247		6.1	5.0	6.7	3,773*	4,032		230	202	233
Mi.	6.6	6.2		3,389	3,076		224	191		7.5	6.8	7.1	—	—		—	—	
Fe.	7.7	6.3		1,901	2,159		146	136		7.3	7.7	7.4	2,762	2,386		202	184	199
Ca	6.6	6.1		2,784	2,688		184	164										

\* Blood protein concentration and blood volume not done on same day.

fed group, one fainted and one who was about to faint was returned to the horizontal position because of the intensity of his subjective complaint. In the control group three of nine patients had continuous intravenous fluids up to the time of the test and cannot be considered with the rest. Of the six remaining, however, three fainted.

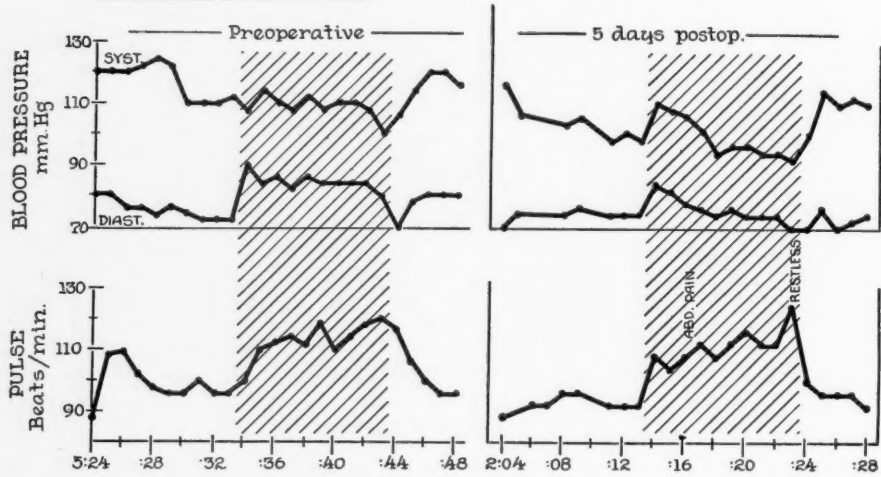
The average drop in systolic blood pressure was almost identical in the two groups. Pulse rate elevations, however, were dissimilar. In the force-fed group the average rise in pulse was 22 beats per minute while in the control group the rise was 32 beats per minute.

If one uses paired experiments to bring out differences in the response of patients treated with varied regimens, some benefits of the force-feeding program become more evident. In selecting pairs with regard to operative procedure and age-group, three general surgical and three neurosurgical pairs can be matched. Three of the paired controls lost consciousness with change of position to the vertical while none of the force-fed partners fainted. Other changes, such as absent radial pulses, excessive sweating, and dizziness in the vertical position were much more evident in the control than in the force-fed group. A comparison of two patients, one prefed and one control, who had gastric resections for peptic ulcer, is illustrated in Figure 1.

*Ballistocardiographic Tracings.*—The ballistocardiographic records from these patients were included in a larger group for analysis. The question of whether patients whose stores of nitrogen were maintained by special methods of feeding before or after operation were in better condition than those who went into more negative nitrogen balance has been the subject of another report under the general title of "Convalescence from Surgical Procedures."<sup>7</sup> It was the impression of the surgeons that those given extra feedings were benefited. Mayock, Koop, Riegel, Kough and Starr<sup>7</sup> believe they have confirmed this. Ballistocardiographic abnormalities occurred much more frequently after operation in all the patients whose nitrogen balances were negative. Inasmuch as both age and type of operative procedure are probably factors in causing these abnormalities, the patients were again paired with reference to operation first and age second. From this type of analysis it was apparent that the individual in better metabolic condition developed fewer ballistic abnormalities after operation than did the patient with whom he was paired. The results were not significant statistically, but, as the authors state in their detailed report, the changes were 92 out of 100 that a negative nitrogen balance is associated with the development of ballistocardiographic abnormalities after operation.

*Clinical Course.*—In spite of the fact that clinical impressions can be misleading, there was enough evidence of a better response in the force-fed group to be convincing to the observer. The differences were most marked in comparing the neurosurgical patients in the two groups. Those who had been force-fed needed ventricular taps for increased intracranial pressure less frequently than did controls. They were ambulatory sooner and showed less postoperative facial edema. Results were more difficult to measure in the general surgical group, but all the force-fed patients had benign postoperative

Sm. age 47  
Gastric resection  
Force fed 0.94 gm. N/Kg. preoperatively.



Fa. age 44  
Gastric resection.  
Control Diet as desired, preoperatively.

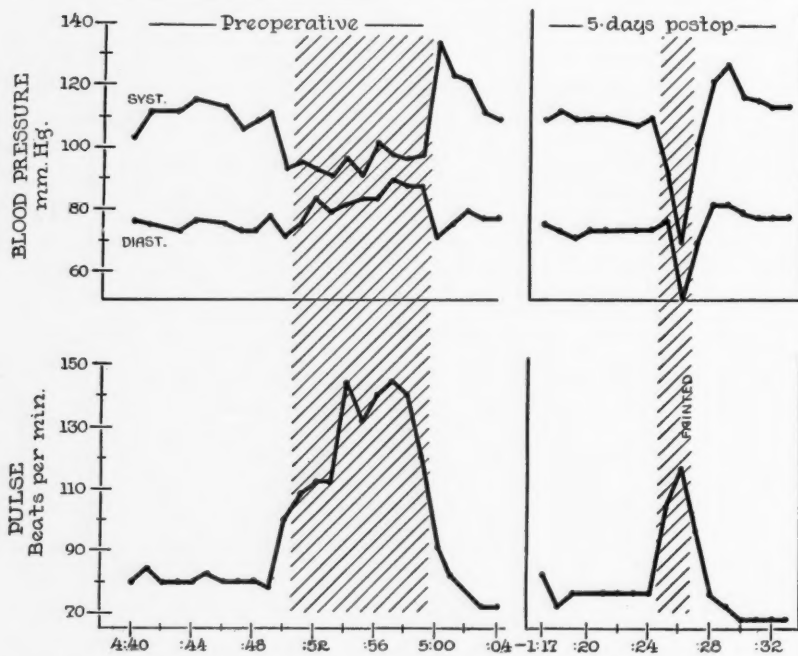


FIG. 1.—The response to tilting in a force-fed patient compared with his control.



courses in spite of the fact that several of them had extensive unavoidably traumatic and time-consuming procedures.

**DISCUSSION.**—It should be stated that the control series was not studied for five days before operation, and for this reason these patients are not controls in the strict sense of the word. It is a reasonable assumption, however, that these patients had either maintained themselves in equilibrium or were in negative balance during the week before operation. There is also a possible question whether or not the extra nitrogen accumulated in the body during the force-feeding period is as readily available during the postoperative period as food nitrogen absorbed from the alimentary tract from day to day. At present we have no reason to doubt that it is as available.

One of the chief objectives of our studies in convalescence and nutrition has been to ascertain if the patients in nitrogen equilibrium responded better to operation than those who were in negative nitrogen balance. It was our impression that a group of patients force-fed preoperatively did respond better after major surgical procedures than did those whose nutrition preoperatively had not been controlled. Some data presented here, and in the detailed reports dealing with circulation and nutrition, support that clinical impression.

Although the nitrogen balances in the two groups for the postoperative periods alone were somewhat less negative in the control group, the group force fed preoperatively were able to draw upon an accumulated store of nitrogen from the five preoperative days and thereby remain in positive cumulative nitrogen balance when the five preoperative and the five postoperative days were considered together.

The response of the circulation to changes in position on a tilt-table, while not as clear-cut in demonstrating the benefits of positive balance because of the number of variables involved, did indicate a higher degree of fitness in the force-fed group.

In those patients who can be fed by mouth, or by tube, it seems logical to spend five days before operation with a vigorous nutritional program at a time when very high nitrogen and caloric intakes are possible and when the patient is in comparative comfort rather than to spend the same number of days postoperatively in attempting to achieve nitrogen equilibrium under trying and difficult circumstances. It was our impression that patients force-fed preoperatively were in better condition on the fifth postoperative day than were patients operated upon without special preparation.

#### CONCLUSIONS

Eleven patients undergoing extensive abdominal or neurosurgical operations were prepared for five days before operation by diets providing them with 0.8 to 0.9 Gm. of nitrogen per kilogram per day. This intake was made possible by supplements of hydrolyzed protein given by tube when necessary. This regimen resulted in a large retention of nitrogen in each individual, averaging 92.2 Gm. per patient for the five-day preoperative period. Except in one instance the positive balance in each case was more than enough to compensate for the negative balance occurring in the five days after operation.

The mean balance per patient for the ten-day period, beginning five days before operation, was +55.2 Gm. of nitrogen.

The retained nitrogen was not stored in general as plasma protein. In fact, the mean total circulating plasma protein decreased moderately in the eight patients in which this was measured, except in the case of the single patient whose initial serum protein level was below 6.0 Gm. per 100 ml.

A group of 12 similar patients who received no special diet before operation were studied for five days postoperatively for comparison. Two tests of physical fitness, the ballistocardiograph and the tilt-table test, supported the clinical impression that the patients maintained in better nutritional condition were in better physical condition as well.

#### REFERENCES

- <sup>1</sup> Co Tui; Wright, A. M.; Mulholland, J. H.; Carabba, V.; Barcham, I. and Vinci, V. J. *ANNALS OF SURGERY*, 120: 99, 1944.
- <sup>2</sup> Riegel, C.; Koop, C. E.; Stevens, L. W. and Rhoads, J. E.: To be published.
- <sup>3</sup> Drew, J.; Koop, C. E., and Grigger, R. P.: To be published.
- <sup>4</sup> Starr, I. and Mayock, R. L.: *Am. J. Med. Sci.*, 210: 701, 1945.
- <sup>5</sup> Starr, I.; Mayock, R. L. and Battles, M. G.: *Am. J. Med. Sci.*, 210: 713, 1945.
- <sup>6</sup> Drew, J. H.; Dripps, R. D. and Comroe, J. H. Jr.: *Anesthesiology*, 6: 44, 1946.
- <sup>7</sup> Mayock, R. L.; Koop, C. E.; Riegel, C.; Kough, N. T. and Starr, I.: To be published, *Amer. J. Med. Sci.*

**DISCUSSION.**—DR. CHARLES C. LUND, Boston, Mass.: Doctor Rhoads, and his collaborators, should be congratulated on carrying out this very difficult type of work. Metabolism studies are time-consuming and difficult to plan, and difficult to carry out in a large number of cases. These results I would interpret in one way slightly different from the way he has done so. He spoke of trying to put in extra amounts of nitrogen in order to accumulate a nitrogen store in the body. I am wondering if we should not think in terms of optimums, and I am wondering if his accumulated store is not merely repair of an unrecognized deficiency. In spite of the fact that these patients had fairly normal protein levels in the blood and tissue, maybe our standards of what is normal are not standards of what could be, or should be, considered optimum.

That brings in the whole problem in differentiation of chemical efficiency of the highly trained athlete, the highly trained soldier, compared with the average individual. The highly trained soldier, the highly trained athlete can run four miles, can keep going for a long time, and can stand surgery in a way that the average patient cannot. I have wondered for a long time whether the fact that the great Doctor McDowell did the first successful oophorotomy, rather than the great surgeons of the early 19th century in Boston or Philadelphia or New York, was not due to the fact that he had patients who were so much tougher than the ladies of the east, and he was able to get away with operations that could not be done in the east.

I think further study along the line of nutrition may show that we must concentrate on optimum supply, and even in a short period we may be able to do things we have not been able to do in the past.

DR. JONATHAN E. RHOADS, Philadelphia, Pa. (closing): I think Doctor Lund's point is very well taken. We have serum protein measurements and plasma volume measurements in most cases which indicate that, with one or two exceptions, these patients were not grossly hypoproteinemic, but it is probable that they were not in optimum condition. However, I think they fairly represent the ordinary patient admitted for surgery whom one would not consider as having any gross nutritional deficiency.

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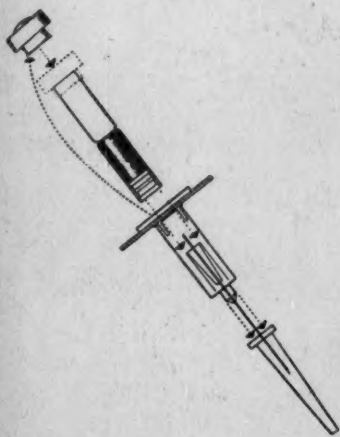
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